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ABSTRACT

This curriculum bulletin is designed to present seventh and eighth graders with an overview of the metalworking industry from the acquisition of raw materials to the fabrication of the completed product. The manual is organized into five major instructional units: sheet metal, wrought metal, jewelry and art metal, bench and machine metal, and cast metal. Each unit is taught from the standpoint of its distinct tools, machines, operations, and processes with a consideration of the relationships that exist between each of the areas. The course provides a dual approach by considering unit and mass production methods of making a product. Each unit contains the following curriculum components: unit production, demonstration and related lesson plans, instruction sheet, related information sheet, mass production methods, occupational information, test questions, alternate product ideas, and selected related materials. In addition to the unit sections, there are comprehensive sections on the course organization, shop management, unit and mass production, course content, guidance, and teaching aids and materials. The manual is illustrated with photographs, charts, and drawings. (CSS)

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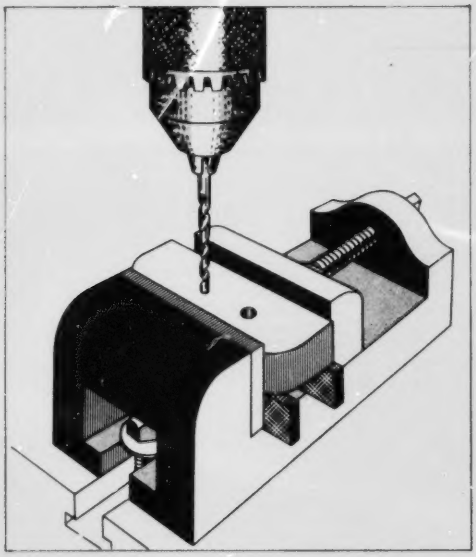
INDUSTRIAL ARTS

METALWORKING

FOR INTERMEDIATE AND JUNIOR HIGH SCHOOLS



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FOREWORD

Metalworking is by far, the largest industry in the nation. It accounts for nearly half of all manufacturing activities in this country. Almost every product made by American industry contains metal parts or is manufactured by machines that are constructed with metal components. The tremendous size and scope of the field of metalworking, as well as its diversity of products and opportunities for employment, makes it an essential area of study in the industrial arts program.

This manual has been organized to aid both the new and experienced industrial arts teacher to upgrade present programs so that each student can derive the maximum benefit from the metalworking course. While the publication is designed to assist the instructor in the teaching of basic metalworking skills and concepts, the intent is also to suggest approaches which will encourage the development of interests, talents, and aspirations. The problem-solving approach is stressed so as to stimulate creative thinking and to challenge the student to use his or her own imagination and initiative. Opportunities for exploratory experiences in the related areas of metalworking not only enrich the student's background, but also provide invaluable information which can be used for the purposes of educational and vocational guidance.

The study of the metalworking industry, from the mining of raw materials to their transformation into finished and functional products is vitally important. Modern metalworking technology has made possible the relatively high standard of living that this country enjoys. The industrial arts metalworking shop furnishes the environment where the operations and processes of the metalworking industry can be demonstrated and the results of the technology can be appreciated.

ARNOLD WEBB
Executive Director

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George R. Quarles, Chief Administrator, Center for Career and Occupational Education, and Charlotte Frank, Unit Head, Curriculum Planning and Policy Unit, supervised the final phases of the project. Leonard Simon, Assistant Director (retired), Bureau of Curriculum Development, and Daniel A. Salmon, Principal of Hillcrest High School, coordinated the initial stages of the project. Herbert Siegel, Director, Industrial Arts, directed the development of the manual.

Arthur E. Golomb, Curriculum Specialist, Center for Career and Occupational Education, was responsible for the design and format. He wrote the text material and served as chairman of the metalworking curriculum committee whose members included: Robert Fixler, Supervisor, Industrial Arts Unit, Philip Kantrowitz, Teacher of Industrial Arts, J.H.S. 96K. The curriculum committee designed the products described in the manual and determined procedures for their production in the school metalworking shops. Donald Pitkoff, Assistant Principal-Supervision, Edward R. Murrow High School prepared the drawings for the manual.

Photographs were made possible through the cooperation of principals, industrial arts supervisors and teachers, and students of the following schools: Myra S. Barnes Intermediate School, 24R; Joseph B. Cavallaro Junior High School, 281K; Hillside Junior High School, 172Q; Seth Low Junior High School, 96K; Louis Pasteur Junior High School, 67Q; and George J. Ryan Junior High School, 216Q. Photographs were taken by Rosario Capotosto, Center for Library, Media and Telecommunications, and Martin L. Kaess, formerly of that center.
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CONTENTS

OBJECTIVES 1

COURSE ORGANIZATION 3
- The Product (Project) 3
- Time Distribution 3
- Multiple Activities 4
- Group Participation 5
- Class Organization 5
- Daily Lesson Plan 7
- Teacher's Plan Book 7
- Student's Notebook 7
- Correlating Metalworking With Other School Subjects 8
- Criteria for Planning 10
- Articulation With High School Metalworking Program 10

SHOP MANAGEMENT 11
- First Session 11
- Shop Tour 11
- Appearance of the Metalworking Shop 11
- Seating Arrangement 12
- Shop Routines 12
- Tool Panel Board 13
- Pupil Personnel Plan 13
- Safety in the Metalworking Shop 17

UNIT AND MASS PRODUCTION 21
- Dual Approach 21
- Advantages of Dual Approach 21
- Unit Production 21
- Mass Production 23

COURSE CONTENT 27
- Implementation 27
- Activities 27
- Related Information 28
- Sheet Metal 30
- Wrought Metal 31
- Jewelry & Art Metal 32
- Bench & Machine Metal 33
- Cast Metal 34

SHEET METAL 35
- Unit Production 36
- Demonstration Lesson Plan Cutting Sheet Metal 40
- Related Lesson Plan Fastening Sheet Metal 41
- Instruction Sheet–Forming A Hem On The Bar Folder 42
- Related Information Sheet– Machinery Application 43
- Mass Production 44
- Mass Production (Alternate) 49
- Occupational Information– Sheet Metal Worker 51
- Test Questions 52
- Alternate Product Ideas 53
- Selected Related Materials 54

WROUGHT METAL 55
- Unit Production 55
- Demonstration Lesson Plan–Riveting 59
- Related Lesson Plan–Forging Metal 60
- Instruction Sheet– How to Spot Weld 61
- Related Information Sheet– Physical Properties of Metals 62
- Mass Production 63
- Occupational Information– Ornamental Iron Worker 68
- Test Questions 69
- Alternate Product Ideas 70
- Selected Related Materials 71

JEWELRY AND ART METAL 73
- Unit Production 74
- Demonstration Lesson Plan– Sawing Thin Gage Metal 78
- Related Lesson Plan– Decorating Metals 79
- Instruction Sheet–Applying Base Coat in Metal Enameling 80
- Instruction Sheet–Surface Decorations in Enameling 81

Related Information Sheet–
Decorating Techniques on Metal 82
Mass Production 83
Occupational Information–Jeweler 88
Test Questions 89
Alternate Product Ideas–Jewelry 90
Alternate Product Ideas–Art Metal 91
Selected Related Materials 92

BENCH AND MACHINE METAL 93
Special Machining Processes 93
Unit Production 95
Demonstration Lesson Plan–Drill
Press Operations 98
Demonstration Lesson Plan–Metal
Lathe Operations 99
Related Lesson Plan–Automation 100
Instruction Sheet–Cutting A Thread
With A Tap 101
Related Information Sheet-Metal
Cutting Machines 102
Related Information Sheet–
Drill Press Operations 103
Mass Production 104
Metal Moldmaking For
Plastic Products 108
Occupational Information–
Machinist 109
Test Questions 111
Alternate Product Ideas 112
Selected Related Materials 113

CAST METALS 115
Administrative Techniques in
the Foundry Area 115
Integrating Foundry With Other
Areas in the Shop 116
Safety in the Foundry Area 116
Unit Production 116
Demonstration Lesson Plan–
Mold Making (Sand) 122
Related Lesson Plan–Alloys 123
Assignment Sheet–Properties
and Applications of Metals 124
Instruction Sheet–
Making a Sand Mold 125
Information Sheet–
Melting Points of Metals 128
Mass Production 129
Occupational Information–
Foundry Technician 129
Test Questions 130
Foundry Equipment Identification
Sheet and Test 131
Alternate Product Ideas 132
Selected Related Materials 133

GUIDANCE
Guidance Function in the
Metalworking Shop 135
Choice of a High School 135
Individual Guidance 136
Proficiency–Interest
Inventory Card 137
Group Guidance 138
Occupational Information Reports 139
Job Titles in Metalworking and
Related Fields 139
Research Report–Occupational
Information 140
Classification of Workers 141
Educational Opportunities 142
Selected Related Materials 143

**TEACHING AIDS AND
MATERIALS** 145
Chalkboard 145
Textbooks 145
Newspapers 145
Magazines 146
Industrial Literature 146
Models 147
Posters and Charts 147
Motion Pictures 148
Single Concept Film Loops 148
Overhead Projector 149
Field Trips 149
Closed Circuit TV and
Videotape Recording 150
Selected Related Materials 151

SELECTED BIBLIOGRAPHY 152

OBJECTIVES

To present a general overview of the metalworking industry from the acquisition of raw materials to the fabrication of the completed product.

To discover the student's interest and talents in the metalworking area which may serve as a basis for making decisions that relate to the choice of a career and/or future education.

To encourage the development of desirable social attitudes by sharing shop responsibilities and working on mass production activities that will benefit the class, school, and the community.

To provide problem-solving activities which will stimulate creative thinking so that each student will be challenged to the limit of his or her capacity.

To improve the written and oral language skills by providing opportunities for self-expression in the form of research projects, committee reports, and other assignments.

To develop an appreciation of past and present cultures which have been expressed in the artifacts and products that have been fabricated from metal.

To emphasize the importance of good design and workmanship in the construction of shop products and commercially produced metal articles.

To relate and reinforce the theoretical learnings of other school subjects to the metalworking area by the application of practical shop problems that are concerned with product design and construction.

To stress the safe handling of tools, machines and materials that are used in the shop and those tools and materials that might be used in the home for repair or leisure-time activity.

To recognize the socio-economic variables that govern the metalworking industry in regard to research and development, marketing and finance, and labor-management relations.

COURSE ORGANIZATION

This course of study, *Industrial Arts Metalworking for Intermediate and Junior High Schools,* incorporates several innovative techniques that are designed to meet the needs of those students who are enrolled in the industrial arts program. While the suggested ideas relating to instructional methods and materials have been developed for the purpose of assisting instructors in planning an effective metalworking program, teachers are encouraged to experiment, to try new approaches, and to develop educational materials that fit their particular circumstances.

This manual organizes the intermediate and junior high school metalworking course into five major instructional units:

SHEET METAL
WROUGHT METAL
JEWELRY AND ART METAL
BENCH AND MACHINE METAL
CAST METAL

Each of the above units represents an important segment within the vast industrial complex that comprises the metalworking field and is taught from the standpoint of its distinct tools, machines, operations, and processes with a consideration of the relationships that exist between each of the areas.

To teach concepts that concern metalworking technology, the course is structured on the basis of the *dual approach*, which entails a consideration of the unit production and the mass production methods of making a product. The dual approach affords the student the opportunity not only to learn, but also to experience the industrial procedures that are required in constructing both the prototype or custom-made article and the mass produced metal article. The dual approach to product fabrication is more fully described in Chapter 3 of this manual.

THE PRODUCT (Project)

The term *product* has been substituted for the *project* as it relates to student output in the metalworking shop. *Product* can be extracted from *production,* and denotes the metal article that is the outcome of a process whether it be developed by unit or mass production. Product more closely identifies the end result of the metalworker's effort in industry and therefore, it should be applied in the school shop environment.

It is suggested that teachers think of each construction activity within the shop in terms of the product rather than the project. By substituting the term product for the traditional project, it will be easier for the students to be reminded that they are involved in the study of industrial processes and the eventual outcomes that result in the form of metal products.

TIME DISTRIBUTION

This course is designed for the 7th and 8th grade students who are programed for the metalworking shop 4 periods per week (two double periods, preferred) for one term. The suggested time allotment is:

CLASS ROUTINES, LESSON	
PRESENTATION	20 MINUTES
WORK SESSION	60 MINUTES
CLEANUP	10 MINUTES
	90 MINUTES

It is recommended that the teacher refrain from presenting lessons that are too time consuming. From the

standpoint of student interest, periodic short lessons, appropriately presented when required during the work session, will prove more beneficial than lengthy ones that affect the students' span of attention.

MULTIPLE ACTIVITIES

To implement the recommended term plan, to provide for the maximum use of shop equipment, and to minimize waiting time for operating a machine or other equipment, it will be necessary for the teacher to divide the class into various working groups. Each of these groups will be working at different activities simultaneously, concentrating on the broad area to which it is assigned. Because work stations in the shop are not evenly divided for each of the major areas in the shop, it may be impractical to divide the class into groups with an equal number of pupils. Variations in group size will depend on the availability of shop facilities.

The organization of the shop into multiple activities will require the use of effective teaching aids. These aids, such as instruction sheets, job sheets, methods boards, and charts will enable the students to answer many of their own questions. In addition, the solid foundation that they acquire during the introductory demonstrations relating to the basic product fabricated in the shop will enable the students to proceed at their assigned work area with a minimum of instruction. This situation will permit the teacher to circulate around the shop, giving individual or group instruction where it is needed.

TERM PLAN A

WEEK 1	INTRODUCTION AND ORIENTATION		
2 3	Unit Production	SHEET METAL	JEWELRY/ART METAL
4	Mass Production	(S.M.)	
5 6	Unit Production	BENCH/MACHINE METAL	WROUGHT METAL
7	Mass Production		(W. M.)
8 9	Unit Production	CAST METAL	SHEET METAL
10	Mass Production	(C.M.)	
11 12	Unit Production	WROUGHT METAL	BENCH/MACHINE METAL
13	Mass Production		(B/M)
14 15	Unit Production	JEWELRY/ART METAL	CAST METAL
16	Mass Production	(J/A)	
17	SUPPLEMENTARY ACTIVITIES		
18	FINAL WEEK ACTIVITIES		

GROUP PARTICIPATION

It should be noted that the products emanating from the mass production activities described in this manual are not overly complex, and have been selected because of their simple design, ease of fabrication, and functional value. Because the relatively uncomplicated, short-term production activities do not require the full participation of the entire class, the required operations can be executed by a smaller group or committee of students, thus affording the teacher greater freedom in assigning students to various work stations along the assembly line. In addition, there is a greater opportunity for student rotation when multiple mass production exercises are programmed during the term.

The teacher must use discretion when assigning students to various groups. Adjustments will be necessary in order to meet the needs of pupils whose individual differences in relation to intellectual capacities and educational background will have to be considered. Students learn and work at different rates of speed; all must be constantly occupied if they are to be motivated or challenged.

The intent of the entire mass production effort is not only to provide an environment in which concepts will be taught concerning the division of labor and the application of labor-saving devices that make possible increased production and lower costs of products, but also to develop desirable social skills and attitudes through the cooperative effort of each member of the class.

TERM PLAN B

WEEK 1	INTRODUCTION AND ORIENTATION		
	UNIT PRODUCTION		
2 3	SHEET METAL	JEWELRY/ART METAL	WROUGHT METAL
4 5	BENCH/MACHINE METAL	SHEET METAL	JEWELRY/ART METAL
6 7	CAST METAL	BENCH/MACHINE METAL	SHEET METAL
8 9	WROUGHT METAL	CAST METAL	BENCH/MACHINE METAL
10 11	JEWELRY/ART METAL	WROUGHT METAL	CAST METAL
	MASS PRODUCTION		
12	SHEET METAL		
13	JEWELRY/ART METAL		
14	WROUGHT METAL		
15	BENCH/MACHINE METAL		
16	CAST METAL		
17	SUPPLEMENTARY ACTIVITIES		
18	FINAL WEEK ACTIVITIES		

CLASS ORGANIZATION

For all practical purposes, eighteen weeks constitute the term's work with allowances for holidays, testing programs, and other school-wide functions. Because of the varying conditions under which the metalworking program is conducted, the term plan must necessarily be flexible to meet local situations that exist throughout the school system.

Suggested Term Plan A

Following the first week's introduction and orientation, the remainder of the term is divided into approximately 5 three-week periods, with the final two weeks scheduled for concluding activities. The 5 three-week segments will permit an exploration into each of the five major industrial areas that have been selected for study. It is suggested that the first two weeks in each of the five areas concentrate on introducing basic skills and knowledge, and applying the learnings in the unit product construction activity. The remaining third week in each of the five industrial areas allows for summarization which may culminate in a mass production activity incorporating operations related to the area under consideration.

Suggested Term Plan B

This alternative approach allows for the scheduling of all mass production activity during the latter part of the term, rather than allotting time at periodic intervals as suggested in plan A. Thus, following the introduction and orientation presentations of the first week, the next ten weeks would be divided into 5 two-week segments, during which time the class would be introduced to the basic skills and knowledge required in implementing unit production activity in each of the five major areas selected for study. The remaining weeks would be devoted to group participation, focusing on a series of mass production activities which would serve as the culminating exercises.

Student shaping bracelet with a file in the Jewelry and Art Metal area

Student using jeweler's saw with metal resting on clamped Vee block

DAILY LESSON PLAN

It is essential that teachers develop their own personal lesson plans for demonstrations and related information lessons. The plan is the guide which enables teachers to present the lesson in a logical manner, and serves as a reminder of the main factors to be covered. Because the lesson should be geared to the type of audience that will observe the presentation, plans must vary to accommodate the differences that exist between one class and another. Thus, while lesson topics or titles may be similar, lessons will vary, where necessary, to meet specific needs of non-English speaking students, slow readers, as well as classes of students who are grouped in SP categories.

The development of the lesson plan is one of the most important responsibilities of metalworking teachers, and it deserves their utmost attention. The effectiveness of instruction depends, to a large extent, on the quality of the lesson plan. It must be structured carefully so that there is a logical sequence. It should follow a prescribed outline which includes such factors as preparation, motivation, presentation, summary and application. Sample lesson plans are contained in subsequent chapters of this manual.

TEACHER'S PLAN BOOK

A handy up-to-date loose leaf plan book is an indispensable aid in organizing the metalworking shop program. The plan book should contain the term calendar, term plan, weekly plan, daily lesson plans, and samples of rexographed instruction or related information sheets that are distributed to the class. The plan book should be revised periodically. New lesson plans should be added, while older materials that are no longer pertinent should be discarded.

STUDENT'S NOTEBOOK

The metalworking program can be enhanced by including the shop requirement that each student be responsible for organizing and developing a metalworking shop notebook. This notebook could serve in a number of ways:

1. Provide the opportunity for practicing language skills. New technical terms could be recorded and defined, drawings and sketches could be labelled, and the spelling could be checked by the instructor.

SUGGESTED LESSON PLAN FORMAT

TITLE	State concisely and accurately
AIM	Pinpoint primary objective
PREPARATION	List equipment and instructional aids required
MOTIVATION	Arouse interest, create desire to learn
PRESENTATION	Describe step-by-step procedure in proper sequence
SUMMARY	Review key points by questioning or listing on chalk board
APPLICATION	Apply knowledge derived from lesson
ASSIGNMENT	Follow up for reinforcement and enrichment
REFERENCE	Indicate sources of information for teacher and student

2. Add another element to be considered in awarding a grade for the term's work.

3. Use as a practical means for retaining handout sheets, reports, assignments, regulations, and other informational material for future reference.

Uniform instructions at the beginning of the term would inform the class of the standards to be expected. Students should be informed that the notebooks are to be inspected periodically and that the books are to be graded for neatness, accuracy, completeness, and originality. The contents could include such items as:

Title Page
Table of Contents
Safety Rules
Shop Regulations
Pupil Personnel Duties
Written Research Assignments
Film Reports
Photographs
Samples—Types of Metals (Foil, Wire)
Field Trip Description
Flow Charts
Working Drawings
Instruction Sheets
Advertisements (Metal Products)
Brochures
Shop Log

CORRELATING METALWORKING WITH OTHER SCHOOL SUBJECTS

Relating the metalworking course to other school subjects not only serves to enrich the metalworking program, but also gives the overall school curriculum more meaning. The value of a school subject is enhanced when the student can apply the knowledge and skills that are learned in one class to solving practical problems in another. In addition, learnings acquired outside the school shop are reinforced when they are applied to activities occurring within the metalworking shop.

The teacher in the metalworking shop should strive to obtain a perspective concerning scope and content of instructional material taught in other subject areas. To acquire this background, the teacher should confer with other members of the school staff and examine courses of study. In addition, the instructor in the shop should inform subject teachers as to what is being taught in the metalworking shop. This could be accompalished by inviting subject teachers to inspect the metalworking shop and to observe the operations being performed. Subject teachers would then be in a better position to relate their lessons to the industrial arts program and to utilize the experiences of those students who have attended, or are presently attending, the industrial arts shop:

Demonstrations, related information lessons, shop talks, written and oral assignments and other teaching activities can be used to indicate the connection between metalworking and the following subject areas:

Metalworking and Language Arts

Opportunities are afforded to enlarge student's vocabulary by learning new technical terms that relate to metalworking.

Correct spelling and sentence structure as evidenced on student's reports, homework, and notebook are checked by teacher.

The notebook is student's record of important information derived from lessons; student describes daily accomplishments in the shop log section of the notebook.

Library skills are practiced by researching assigned topics.

Dictionary and handbooks are readily available and used in the shop library.

The student submits a list of sequential steps that were followed in product development and construction.

Orderly arrangement of data is required in developing production flow charts and bills of materials.

Oral presentations relating to products and processes permit student to gain experience and confidence in expressing ideas to a group.

Following directions as specified by safety rules demands complete comprehension of safety regulations.

Metalworking and Mathematics

Costs are computed for materials, labor, tools and machines required in fabricating products.

Mathematical formulas are used for determining cutting feeds and speeds.

Decimals and fractions are used on blueprints to designate tolerances.

Percentages relating to chemical composition of alloys are examined.

Geometric shapes are constructed in the layout of patterns and designs.

Ratios are considered in simple machine principles – lever, pulleys.

Graphs are studied to determine production output.

Logical approach to problem solving.

Measuring devices are used to determine size and to control the quality of product.

Practical applications of mathematical principles in designing products.

Introduction to computers and numerical control.

Metalworking and Social Studies

Metalworking through the ages – bronze age, iron age, space age.

The continuing scientific revolution; new alloys and processes.

Sources of raw materials; geographical location.

Conserving natural resources; using materials that can be grown or reproduced vs. mineral extraction.

Automation and the displacement of workers.

Higher standard of living resulting from mass production.

Inventors and innovators in metals technology and production.

The role of labor organizations; labor-management problems.

Job opportunities and trends in metalworking.

Consumer education; advertising claims for metal products.

Metalworking and Science

Techniques of research that are learned in the science room are practiced in the shop.

Physical and chemical properties of metals are studied.

Chemical symbols and simple equations are introduced.

Simple machine principles are analyzed and applied to metalworking equipment.

Substitutes for metals by synthetic materials.

Exotic metals in space age exploration.

Power sources for metalworking machines.

Conversion of raw materials into refined metals.

Automation and the interchangeability of parts; quality control methods.

Application of the scientific method to problem solving.

Air and water pollution resulting from industrial wastes of metal processing plants.

Metalworking and Art

Appreciation of good design in product development.

Metal as an art medium – cast and welded sculpture; jewelry and art metal.

Role of the industrial designer.

Visual representation techniques for metal products.

Safety posters in the shop produced by students.

Use of metal as an architectural material.

Designing a product in the metalworking shop.

Decorative techniques in metalworking – engraving, embossing, etching.

Metalworking and Health Education

Safe use of tools and machines.

Safety in the home.

Importance of adequate lighting and ventilation.

Fire prevention in the use of inflammable materials.

Muscular coordination in the use of tools and machines.

Hazardous clothing in the shop.

Use of safety equipment.

Need for cleanliness and neatness in metalworking shop.

Metalworking as a leisure time activity.

CRITERIA FOR PLANNING

As teachers organize and develop their course for the metalworking shop, they should always be cognizant of the purposes of the industrial arts program. They should keep in mind those insights, concepts, and skills that are expressed in the course of study. Because the scope of the metalworking industry is so extensive, only those activities that will be most meaningful to the student should be selected. In order to determine how and to what extent educational material should be presented to the class, the teacher will be required to consider the following criteria:

Time Allotment

Is sufficient time available to demonstrate those metalworking processes that have been selected?

Has provision been made for holidays, cleanup, tests, and assembly programs?

Can assigned activities outside the school and product construction within the shop be completed within estimated time schedules?

Student Backgrounds

Are instructions geared to the student's ability to understand the concepts?

Does the program encourage the development of leadership qualities?

Are the more talented students being challenged sufficiently?

Is the program being adjusted for the slow learner?

Machines and Materials

Are materials available and in sufficient quantities?

Are the machines in working condition and ready to function?

Is all necessary auxiliary equipment to demonstrate a machine operation readily obtainable?

Safety

Is safety stressed in each demonstration and related information lesson?

Are there a sufficient number of safety tests given at periodic intervals throughout the term?

Is the safety supervisor informed of the specific responsibilities?

Are the students acquainted with safe operational procedures for each piece of equipment in the shop?

Evaluation

Are the objectives of the course being attained?

What tests and measurements can be used to determine the student's progress?

How can the metalworking program be improved?

ARTICULATION WITH HIGH SCHOOL METALWORKING PROGRAM

At the intermediate and junior high school level, the industrial arts metalworking program is primarily exploratory — developing basic skills, stressing broad concepts, introducing occupational information, and emphasizing the correlation with other school subjects. After students progress to the high school, with their increased knowledge, skill and manual dexterity, they are capable of acquiring a cluster of skills that permit more complex construction activities, and a greater "in depth" study of metalworking technology.

Correlating Language Arts with Metalworking

SHOP MANAGEMENT

An efficient managerial plan for administering the metalworking shop is a prime requisite, not only for teaching effectively, but also for reducing discipline problems and preventing hazardous conditions within the school shop. From an educational standpoint, shop management procedures can serve as the medium for developing qualities of individual responsibility and group leadership, as well as providing insights into supervisory services that make tool and machine production possible.

Managing the metalworking shop in the school reflects, to a large degree, the management problems that confront the metalworking industry. Just as the metalworking classes in school are concerned with safety, inventory, product storage, personnel organization, and other related factors, so too are the various metalworking plants that comprise the vast metalworking industry. Thus, the managerial techniques that are required to administer the metalworking shop in the schools should indicate, in some measure, how industry expedites its managerial functions. The role of the computer and job opportunities related to management personnel will enrich related information lessons that are concerned with industrial management.

It is suggested that the Bureau of Curriculum Development bulletins, *Teachers Guide to Industrial Arts Shop Management*, 1964-65, No. 9 and *School Shop Safety Manual*, 1964-65, No. 13, be used as reference sources in conjunction with this chapter.

FIRST SESSION

During the first meeting of the class, it is imperative that the metalworking teacher set the tone of the shop. The teacher must establish the image that he or she is both firm and fair, will not tolerate any breach of discipline, and that the students are expected to meet their responsibilities. The instructor must also arouse the students' curiosity and motivate the class so that they will be eager to pursue the course. This can be accomplished by making the shop as attractive as possible, displaying metal products that were constructed by the students, and "selling the program" by explaining how and why the metalworking program will benefit them as potential employees in the metalworking industry, future owners of small businesses related to metalworking, or as consumers of metal products.

SHOP TOUR

The shop tour constitutes an excellent technique for introducing the metalworking program to the class. After the routine matters of the first session have been completed, a brief tour of the shop can serve as a motivational procedure for describing the overall metalworking course. Most students will be unacquainted with the equipment in the shop, and will evince a sincere interest as the teacher leads the group to various sections of the room to explain briefly the functioning of the metalworking tools and machines. A greater degree of interest will be generated if the teacher demonstrates one or two simple operations, such as bending a hem on the bar folder, drilling a hole on the drill press, or turning cylindrical stock on the lathe.

APPEARANCE OF THE

The appearance of the shop reflects the attitude of the instructor. The shop room, if properly maintained, can

be a key factor in the success of the metalworking program. Therefore, it is essential that the shop be an attractive center of learning within the school building, where students will want to visit or work with tools and machines. Interesting displays, colorful charts, commercial exhibits, and models of students' work will not only enhance the appearance of the shop but will evoke interest on the part of the students attending the sessions. Neatness and cleanliness will also establish an environment that is conducive to learning, and will reduce problems relating to discipline and safety.

The image of a smooth running shop is strengthened when machines are properly cleaned and maintained, the tool panel carefully arranged and labelled and materials neatly stored and available when required.

SEATING ARRANGEMENT

At the beginning of the term, after class registers have been stabilized, each student should be assigned a permanent seat or work station where he or she must report at the beginning and end of each session. The seating arrangement can be determined by alphabetical order, or other system deemed satisfactory by the teacher. The advantage of requiring each student to sit at a specific location is that it permits a visual checkup by the teacher of student attendance. It eliminates the need for calling out names, which wastes time and can be a disrupting influence on the class. Painting or stenciling a number on the benches and work stations to coincide with the number adjacent to each student's name that is recorded on the Progress Chart will make it easier for the pupil to remember the assigned location.

SHOP ROUTINES

The shop routines must be clearly explained at the first meeting of the term. Each class must be made aware of the responsibilities, and recognize the reasons for the establishment of specific procedures for entering the room or stopping work when the signal is given. A list of student responsibilities as they relate to shop routines can be duplicated for each mem-

SHOP ROUTINES

Industrial Arts Metalworking Shop	
1.	Enter the metalworking shop on time and through the proper door.
2.	Remove coat or sweater and hang on hook.
3.	Place books on shelf – not on the top of work bench.
4.	Put on apron and roll sleeves above the elbow.
5.	Sit quietly in assigned seat for attendance check.
6.	Raise your hand during lesson if you wish to ask or answer a question.
7.	During work session, return tools to tool panel immediately after you have finished using them.
8.	Ask permission of the teacher if you wish to leave the room. Sign out and take the room pass. When you return, sign in and hang room pass on hook.
9.	Stop work when the cleanup signal is given.
10.	Return equipment to the proper place. Store work in locker.
11.	Perform cleanup assignment.
12.	Wash hands and deposit paper towel in the trash container.
13.	Return to assigned seat, open notebook and fill in shop log.
14.	Talk to neighbor in a conversational tone. Do not shout or talk loudly.
15.	Await permission of teacher to leave room through proper exit.

ber of the class, distributed, and inserted in the student's shop notebook.

TOOL PANEL BOARD

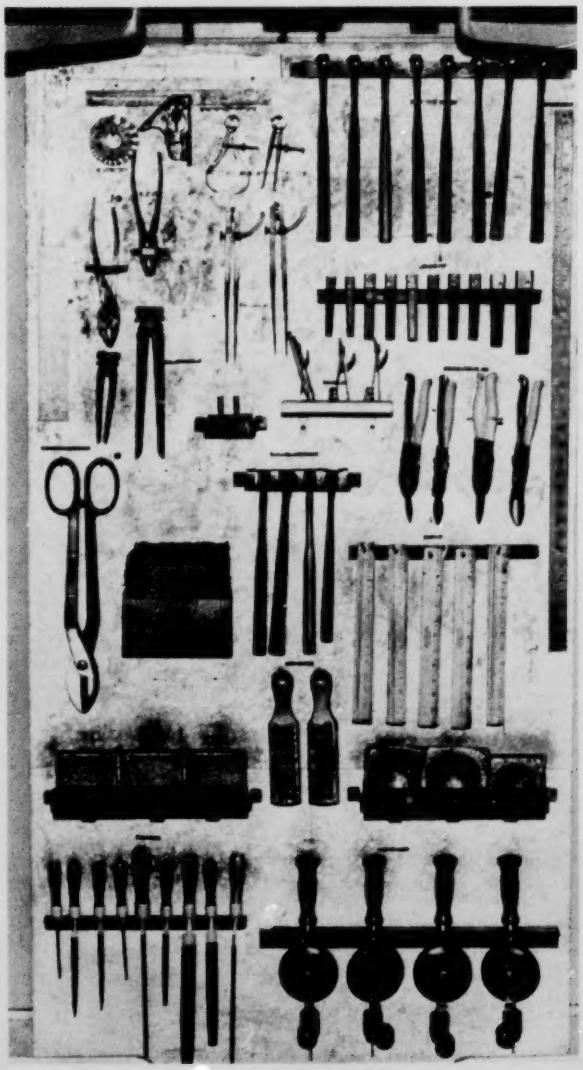
The most common system of storing and distributing hand tools and small equipment for everyday operations is the use of the tool panel board. This method is convenient since it allows the student to readily select the tools needed from an open panel, and provides for rapid inspection to determine if all tools have been returned. Numbers, names, or silhouettes painted or stencilled on the panel board to identify tools and to indicate their specific locations will expedite the student's returning and placing the tools in the designated storage space on the board.

Strict control of the tool panel board at all times throughout the term is mandatory, for it is not only costly, but dangerous to have tools removed from the shop without the knowledge and permission of the teacher. One or two students, depending on class size, can be assigned the responsibility of administering the distribution, return, and checkup of tools. It is most important that the checkup be executed carefully at the beginning of the period, as well as at the end, so as to ascertain whether any tools were missing from the previous class. Students assigned to the tool panel board should be cognizant of what is required in their inspection. The inspection should include an accurate count of the number of tools that are contained on the panel board at the beginning and end of the session, and should entail an evaluation of the condition of the tools – whether they are damaged, need sharpening, or should be replaced.

PUPIL PERSONNEL PLAN

A well-organized pupil personnel plan is essential to a smooth running metalworking shop. The plan must be structured so that all required chores are completed satisfactorily by all students prior to class dismissal. Good discipline in the shop is dependent upon an efficient personnel system in which each class member fulfills his obligations as stated in the plan.

At the start of the term, assignments must be made. These can be listed on the Progress Chart, or on a special chart designed specifically for the particular shop by the instructor. Regular rotation will prevent any complaint of unfair assignments. Students must know beforehand what they are expected to do. Therefore, each assignment must be clearly delineated. It is advisable to duplicate copies of specific duties that are prescribed for each assignment so that there can be no uncertainty as to what should be done. Students should file a copy of the pupil personnel plan in their notebook so that they can refer to their individual duties. Periodic evaluation should be made by the teacher to determine student efficiency in performing the designated responsibilities.



A well-organized tool panel board

PUPIL PERSONNEL PLAN

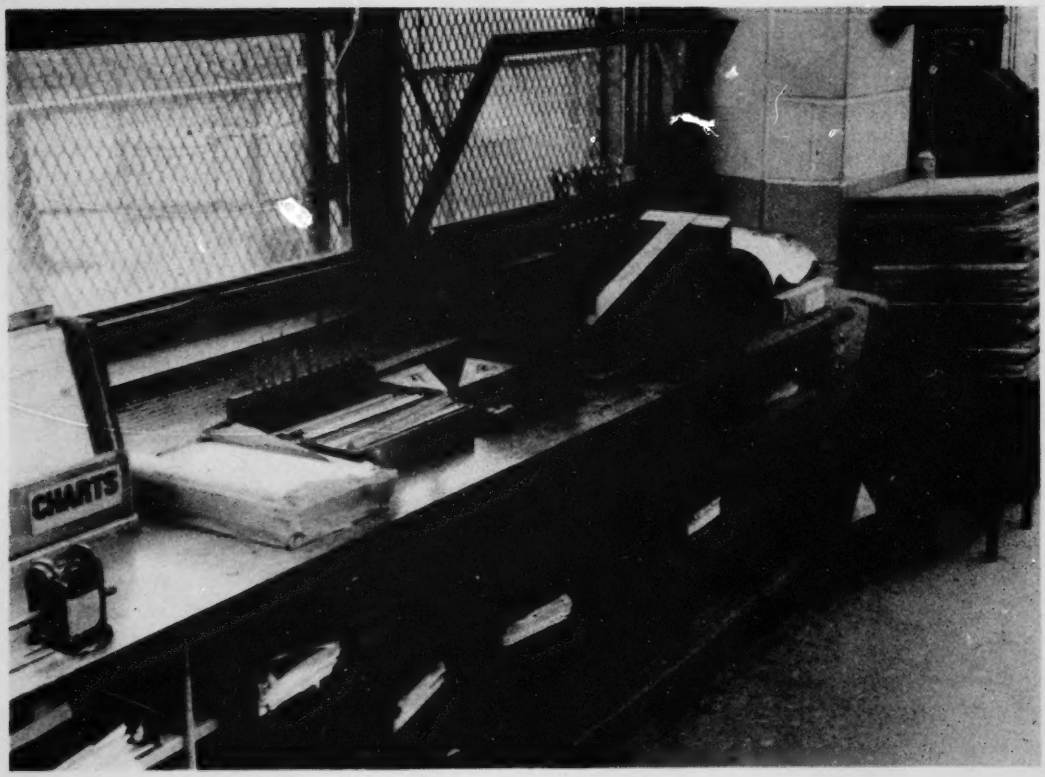
Assignment	Description of Assignments
Superintendent	Coordinates work of all personnel. Assigns students to various positions by rotation. Informs teacher when all cleanup and other assignments have been satisfactorily completed. Appoints substitutes for absentee students. Gives cleanup signal when directed by the teacher. Assists teacher in administrative tasks.
Assistant Superintendent	Assumes duties of superintendent when the superintendent is absent. Assists teacher and superintendent in carrying out administrative tasks. Assigns substitutes for absentee students. Reports to superintendent when cleanup is completed satisfactorily.
Tool Panel Supervisor	Checks tool panel for missing tools at the beginning of period. Checks that all tools are returned before class is dismissed. Reports all missing tools to teacher and superintendent. Inspects tools for breakage. Records names and dates of missing tools on list attached to tool panel.
Safety Supervisor	Maintains record of safety tests on Progress Chart. Makes daily inspection of shop for shop hazards. Keeps folder containing safety rules in a neat and orderly manner. Inspects attire of students: sleeves rolled up; apron strings tied in back. Checks all gas valves; must be in "OFF" position at end of period.

PUPIL PERSONNEL PLAN

Assignment	Description of Assignments
Floor Supervisor	Cleans floor: under benches, machines, corners. Places usable materials in salvage container. Shovels trash into receptacle. Returns broom and shovel to proper storage area.
Machine Supervisor	Checks condition of machines at beginning and end of the session. Checks to see if all tools and accessories are in proper place. Keeps machines oiled. Makes sure that all guards are in use.
Planning Center Supervisor	Arranges books and magazines in a neat and orderly manner. Checks drawing boards, T squares and rulers. Inspects equipment for damage.
Soldering Bench Supervisor	Inspects soldering bench for missing tools. Checks that gas and air lines are shut off. Makes sure that flux, solder, and soldering irons are all properly stored. Dusts off bench at end of work session.
Sanitation Supervisor	Refills soap and towel containers as needed. Makes sure that floor area in vicinity of sink is kept dry. Checks that all towels have been deposited in trash can. Cleans sink after use by class. Keeps sink free of debris.

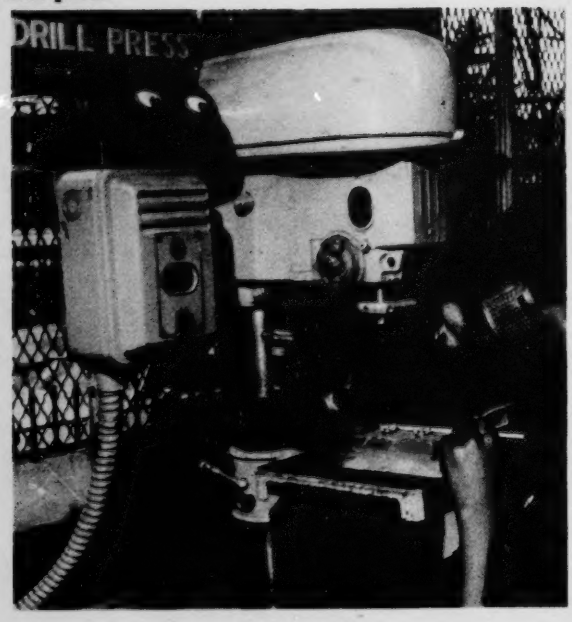
PUPIL PERSONNEL PLAN

Assignment	Description of Assignments
Supplies Supervisor	Distributes materials with teacher's permission. Maintains inventory of supplies given out to class. Informs superintendent of items that are in short supply; lists materials that are in need of replacement. Arranges supplies in storage cabinet and shelves in a neat and orderly manner. Prepares materials for distribution: kits of fasteners, precut metals.
Locker Supervisor	Checks lockers at end of period to make sure all lockers are closed and secure. Places neatly lettered label on locker door to indicate students assigned to locker. Inspects lockers periodically and removes materials that are in excess. Records combinations for all combination locks. Card file will be kept in the possession of the teacher.
Bench Supervisor	Cleans bench tops: no chips or oil on surface. Returns any tools that remain to tool panel. Inspects condition of bench for damage. Checks all areas around bench vises to make sure they are clean and free of chips. Places usable materials in salvage container.
Finishing Area Supervisor	Inspects area to see that it is clean and orderly. Deposits all paint and oily rags in metal containers. Maintains finishing cabinet in a neat and orderly manner. Supervises storage of products that require drying period after application of finish.
Visual Aids Supervisor	Inspects wall posters to see that they are fastened securely. Changes bulletin board materials. Sets up and operates projector. Assists in setting up exhibit of students' work in shop and school display cabinets.



Neat storage of notebooks and drawing equipment

Safe machine practice — Using the drill press



SAFETY IN THE METALWORKING SHOP

The teacher is responsible for implementing a comprehensive and continuous program of safety education in the metalworking shop. Hazards do exist in the handling of metals, the use of tools and machines, and in the operation of heating devices. Because the safety and health of every student is the paramount concern of the metalworking teacher, it is essential that safety be emphasized and that the regulations be enforced. Students must be constantly reminded of the importance of taking precautions and heeding the teacher's instructions in order to avoid accidents to themselves and others in the class.

It is suggested that the metalworking teacher refer to the specific regulations relating to the operation and maintenance of the shop as outlined in the *School Shop Safety Manual*. This curriculum bulletin is an indispensable guide which will assist the teacher in organizing the safety program in the metalworking shop.

Preparation for Classes

Good planning for metalworking shop classes includes careful consideration of the physical conditions which play an important part in the health and safety of each student. The proper physical environment within the shop can reduce accidents and is more conducive to learning. Satisfactory lighting, comfortable room temperatures, and adequate ventilation are all factors that affect the learning situation. Therefore, the teacher must be alert to the physical changes occurring in the room and make those adjustments that are within the control of the instructor.

In addition to attending to the physical requirements of the metalworking shop, preparing teaching materials in advance, rather than while the class is in session, will enable the teacher to focus attention on the behavior of the class. Furthermore, prior preparation enables the students to be ready for immediate class work the moment they enter the shop; keeps them occupied in useful activity so that accident-producing situations resulting from inattentiveness, idleness, or playing pranks on classmates are avoided.

PROCEDURE FOR THE IMPLEMENTATION OF SAFETY

An effective safety program can be implemented if the following suggestions are followed:

1. Carefully explain, demonstrate, and, if necessary, dramatize the safety regulations at the beginning of the term. Make sure that every student understands the terminology and meaning of each regulation.

2. Ascertain such physical deficiencies as poor eyesight or hearing of students by referring to personal records or observation. Gear program to meet the needs of students with physical deficiencies. Note student behavior in the shop. Be on the alert for abnormal actions and consult with school counselors for further data.

3. Teach "safety" in every lesson. Some aspect of safety can be emphasized in the demonstration, related information lesson or shop talk.

4. Test student's knowledge and understanding of safety instruction by conducting periodic formal examinations and informal quizzes.

5. Remind students of the importance of safety by displaying charts and safety posters. These visual aids can be commercially prepared or designed and executed by students.

6. Show safety film such as "Working Safety in the Shop" which can be obtained from the Bureau of Audio-Visual Instruction, Board of Education, New York City.

7. Maintain shop in a clean and orderly fashion. Materials must be neatly stored. Tools must be arranged systematically and held securely on the tool panel. Floors must be free of debris and oil.

8. Be on the alert for abnormal sounds resulting from incorrect tool or machine operation. Oftentimes, a dull cutting edge, or excessive speeds, will cause vibrations that will signal danger to a knowledgeable machine operator.

9. Inspect shop equipment daily to determine proper working conditions.

10. Develop an effective personnel plan in which each student clearly understands the assigned responsibilities and carries them out.

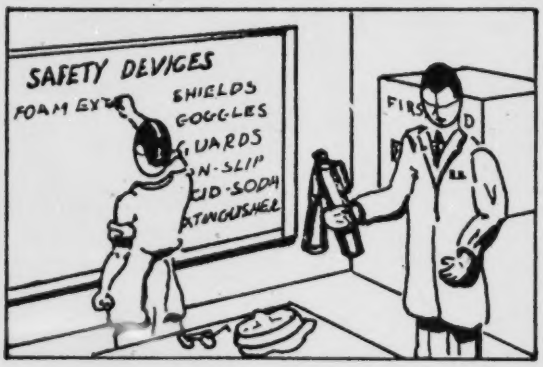
Safety Examinations

The metalworking teacher is required to administer safety tests at the beginning of the term and throughout the term as new tool and machine processes are taught. Sample questions and tests relating to safety in the metalworking shop are contained in the *School Shop Safety Manual.* A variety of tests can be developed by the teacher. These tests can be of the objective type, such as multiple choice, completion or true and false. Short essay-type tests directing students to answer the questions in complete sentences can also provide some feedback as to the students' comprehension of safety regulations.

Safety tests can also serve as valuable teaching devices. Following the administration of each test, there should be a review of the test to clarify the students' understanding of safety procedures.

General Safety Rules

1. Do not enter the metalworking shop unless the teacher is present.
2. Do not use any tool or machine until you have been instructed in its proper use and have received permission from the teacher to use the equipment.
3. Do not run in the metalworking shop.
4. Report all accidents immediately to the teacher, no matter how slight the injury.
5. Pass tools and materials carefully to other students.
6. Do not carry tools in pocket.
7. Cut away from the body when using sharp edged tools.
8. Use a brush to clear away chips or metal dust.
9. Do not wear rings while working on power equipment.
10. Keep steel wool slivers away from hands and eyes.
11. Wear your apron in the shop.
12. Stop work at the signal from the teacher and wait for the teacher's instructions.



Safety Pledge

This is to certify that I have received both verbal and printed instructions in Shop Safety which I understand. I realize that failure to observe these rules may lead to serious consequences. Therefore, to avoid injury to myself and/or to others, I promise to observe these rules carefully and faithfully.

Student's signature .....

Official Class ..... Date .....

Industrial Arts Metalworking Class .....

SAFETY CODE: Power Driven Machines

1. I will ask the teacher's permission before using a machine.
2. I will use the machine only if I am thoroughly familiar with its operation.
3. I will wear safety goggles while operating a machine.
4. I will keep fingers away from cutter or moving parts.
5. I will not talk to anyone while operating a machine.
6. I will stop the machine immediately if there is an unusual sound or vibration, and will inform the teacher that the machine is not operating properly.
7. I will keep loose clothing, rags, and cotton waste away from the cutter and moving parts.
8. I will make sure that guards are in place before operating the machine.
9. I will oil, clean, or adjust the machine only when it has stopped.
10. I will not attempt to slow down or stop the machine with my hands.
11. I will shut off the machine when I have completed the operation.
12. I will remove chips from the work with a brush and *only* when the machine has stopped.
13. I will not strain the cutting tool by taking too deep a cut at too fast a speed.
14. I will not enter the safety zone painted around each machine if another student is using the machine.
15. I will remove the chuck key immediately after tightening the chuck.

Date ..... Student's Signature .....

UNIT and MASS PRODUCTION

The industrial arts metalworking program in the intermediate and junior high school places the emphasis, to a greater degree than in the past, on industrial technology and management. The traditional metalworking course which was centered on the development of those metalworking skills that were required in project construction is being transformed into a program that broadens the scope by the application of the dual approach (unit and mass production) to product development and fabrication.

DUAL APPROACH

The dual approach to the teaching of metalworking at the intermediate and junior high school level envisions a study of unit production and mass production methods with a consideration of pre-production and post-production factors such as material acquisition and product distribution.

It is acknowledged at the outset that the program must necessarily be general and exploratory. While every effort should be made to simulate industrial procedures within the shop, there are limitations that must be recognized. These include the students' capacity to absorb technical data and to execute skills, availability of materials and equipment, and time allotted for programming. Therefore, while the direction of the course should be focused on industrial methods that relate to the manufacture of metal products, limitations will require modifications and adaptations for each individual shop.

ADVANTAGES OF THE DUAL APPROACH

By utilizing the dual approach to product fabrication, several benefits are accrued:

Metalworking course is updated by reflecting modern concepts and techniques.

Students can compare and evaluate unit and mass production systems from the standpoint of efficiency, humanpower requirements, and costs.

Need for delineating supervisory and administrative responsibilities becomes apparent.

Problem-solving is extended to product design, operation and processes, marketing and distribution.

Value of group participation and cooperation becomes evident.

More comprehensive coverage of job categories relating to metalworking and allied employment opportunities: designer, supervisor, engineer, technician, salesperson, adviser.

Increased productivity of the shop can serve as a public relations factor by the distribution of products to members of the school and community.

Correlation with other school subjects becomes more meaningful as relationships with metalworking are recognized: economic, social and scientific.

UNIT PRODUCTION

Each of the five major areas in the metalworking shop can be introduced from the standpoint of a unit production activity involving the making of a prototype or single unit product. Developing metal products within the school shop serves as the medium for teach-

ing hand and machine skills. While it is possible to acquaint students with metalworking processes by means of verbal explanations or visual presentations, concepts, skills and knowledge become more meaningful when pupils actually participate in transforming raw metal stock into attractive and useful objects.

The unit production activity is undertaken by the entire class at the beginning of the term, and then periodically throughout the term when a new area of activity is introduced. It entails fundamental operations that are basic to the metalworking area under consideration in the shop. Thus, the unit production activity would be expedited in each of the five major areas of the metalworking shop program.

Generally, all students are assigned to the making of a prototype, during which time certain manipulative skills are taught and creative talents are revealed. To provide sufficient time to explore all areas in the metalworking shop, the unit production activity must necessarily be of relatively short duration requiring a minimum of time, and be within the range of capabilities of most of the students.

Prototype Development

The initial unit production activity in each of the major metalworking areas of the shop involving the making of the prototype can be administered in a manner which will encourage the students to use their imagination, solve problems, and derive other educational values. If properly approached, the development of the product, from the origin of the idea to the completed item, can serve as the medium for promoting creative thinking.

The teacher should challenge the students so that they work to their fullest potential to solve problems relating to product design and construction. Rather than dictate every aspect of an item to be made in the shop, the teacher should motivate the class by eliciting participation in the development of the product. The instructor should, at least, indicate the options that are available not only in design, but in the methods of construction. Greater educational benefits will accrue if the product evolves as a result of the group's thinking and participation.

Under the guidance and direction of the instructor, the class can examine such factors prior to the actual construction of the prototype:

Function – purpose of product and how it will be used

Shape and size of product

Material – properties required; cost and availability

Type of finish – appearance and protection

Construction methods – unit and mass production possibilities

Designing the Protoype

To illustrate how the unit production activity might be introduced in one of the five major areas of the metalworking course, the following example is cited. By carefully selecting questions, the approach can be used in starting students to work in the jewelry and art metal phase of their program.

The teacher shows the class a key ring which holds several keys; he describes the difficulty encountered when the keys are lost; and asks the class how it would be possible for the finder to return the lost keys to the proper owner. The teacher then elicits the responses to the following questions:

1. How could the key ring be identified?
2. What materials would be suitable for making the identification tag?
3. Why would one material selected be better than another?
4. What would be a convenient size? Shape?
5. How can the name be recorded on the tag?
6. How should the tag be finished? To prevent rust? For appearance?

In all cases, the questions are stated in simple, uncomplicated terms, and wherever possible are based on the experiences of the pupils. The objectives are to motivate, to encourage thinking, and to develop an appreciation of the problems that are involved in creating a product based on the unit production system.

Procedure for Expediting Unit Production Activity

After the preliminary discussion concerning the size, material, and design of the identification tag has been terminated, the students should prepare a working

drawing or sketch which will contain salient information for making the item.

When the material has been distributed, the students should follow the procedure that is described on the operation sheet. After the blank has been squared up to the required dimensions, it should be submitted for inspection. If approval is obtained for correct size and squareness, the students should present the design of their choice for the teacher's approval, and then continue as instructed on the operation sheet.

Upon completion of this unit production activity, the students will have had the experience of performing fundamental operations in measuring, laying out, squaring stock to size, cutting, drilling, filing, finishing, stamping, and inspecting. The experience gained will be invaluable for expediting mass production activity, which usually follows the unit production activity.

It is suggested that while the basic overall dimensions be retained, experimentation should be encouraged by allowing for individual designs and using different materials — aluminum, copper, bronze, nickel and silver. Engraving may be substituted for punch stamping.

During the introductory discussion, students should be made aware of the possibilities of mass production methods with punch presses, dies, assembly lines. There should also be some indication of the practicality of substituting nonmetallic substances, such as plastics for metals, in producing identification tags.

MASS PRODUCTION

Teaching mass production concepts is an integral part of the metalworking program. The system of mass production has played a significant role in human progress and in raising the standard of living for millions of persons throughout the world. It is one of the factors that differentiates underdeveloped nations from those countries that possess highly complex organizations for production.

It is important that students understand and appreciate the system of production that increases volume at lower costs. They should realize that mass production in industry combines the following four basic essentials into a continuous manufacturing process:

Interchangeability of parts

Automatic conveyance of work from work stations in the proper sequence

Division of labor (repetitive operations by single employee)

Elimination of individual waste motion

Mass Production in the School Shop

In the school metalworking shop, it is possible to duplicate some of the situations that are encountered in industry as they relate to mass production techniques. In the chapters that follow, there are suggested mass production activities that are representative of the various areas of the metalworking industry. However, in each instance, attention is paid to the production phase by the inclusion of a production flow chart which illustrates possible work stations and operation sequences. It will therefore be necessary for the teacher to organize the mass production activity so that preproduction and postproduction factors will be considered so that the experience will be a well-rounded one.

The guidance of the metalworking teacher is essential, and discretion will be needed in assigning responsibilities to those who have demonstrated capabilities which will enable them to fulfill their duties.

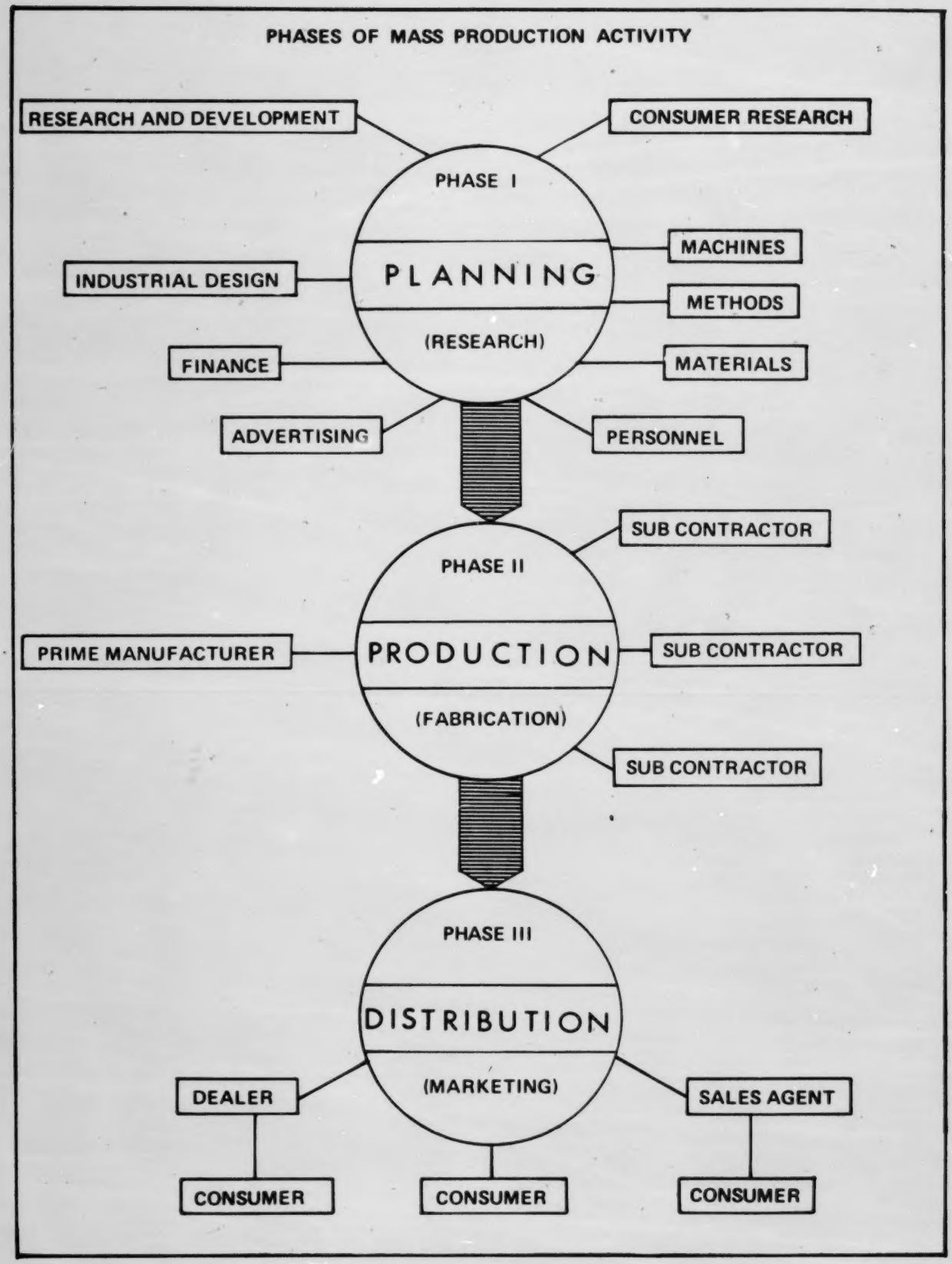
Phases of Mass Production Activity

Essentially, the mass production system can be organized into three basic divisions each of which is closely related to the other. These divisions include:

PLANNING PHASE	The preproduction stage entails all of the preparation that is required for producing and distributing the product.
PRODUCTION PHASE	The fabrication stage involves the output resulting from the sequential tool and machine operations that transfer materials into completed products.
DISTRIBUTION PHASE	The postproduction stage is devoted to the marketing procedures that enable the products to be distributed to the consumer.

STAGE ONE: *Planning*

The initial phase of the mass production system requires an examination of all the factors that must be considered from the conceptual idea of a potential product to its ultimate use by the consumer. In industry, professional personnel with specialized skills


PHASES OF MASS PRODUCTION ACTIVITY
RESEARCH AND DEVELOPMENT
CONSUMER RESEARCH
PHASE I
PLANNING
(RESEARCH)
INDUSTRIAL DESIGN
FINANCE
ADVERTISING
MACHINES
METHODS
MATERIALS
PERSONNEL
SUB CONTRACTOR
PHASE II
PRODUCTION
(FABRICATION)
PRIME MANUFACTURER
SUB CONTRACTOR
SUB CONTRACTOR
PHASE III
DISTRIBUTION
(MARKETING)
DEALER
SALES AGENT
CONSUMER
CONSUMER
CONSUMER

and backgrounds are responsible for formulating decisions relating to the design of the product, financing the undertaking, selecting materials and equipment, and determining work force needs.

In the school metalworking shop, responsibilities can be delegated to selected students or groups of students so that there is a semblance of industrial procedure in the planning-preparation phase. Through class discussion, problems can be presented by the teacher, assignments can be made, and committees can be formed to delve into some facet of design, tooling, and wage scales for skilled workers. It is also possible to provide minimal designing activity to improve or modify those designs that are suggested by other students. With the teacher's assistance, tools and fixtures can be studied for possible use in the shop.

STAGE TWO: *Production*

After the planning stage has been completed, it is then feasible to organize the production phase of the mass production activity. In the school metalworking shop, the shift from unit production activity to mass production activity can be readily accomplished. The students will have used the basic tools and machines, and will have acquired fundamental skills in their operation so that they will be in a position to apply the skills and knowledge learned in prototype construction to volume production.

STAGE THREE: *Distribution*

The final phase of the mass production activity is concerned with the procedures to follow in disposing of the products that are emanating from the assembly line. It becomes obvious that this stage is as important as the two preceding stages, and that each phase is dependent on the other. Therefore, marketing the product becomes very important since the employment of workers and degree of profit or loss for owners or investors of the manufacturing plant depend upon the success of distribution.

Experience can be gained in the distribution aspects of the product. A committee within the shop can be assigned the task of determining how and where mass produced metal items fabricated in the shop can be distributed. The committee can investigate the practicality of marketing the product in the school G.O. store or selling the metal items to members of the parents association. Further outlets for distribution might include the Red Cross, Salvation Army or similar institutions.

Supplementary Approaches to Teaching Mass Production Concepts

In addition to the actual involvement of students in mass production activity within the metalworking shop, other approaches should be utilized to reinforce concepts that relate to mass production methods. A field trip to a local manufacturing plant would be a most informative visit for the students who would be in a position to observe the division of labor and the use of labor-saving devices. Where a field trip cannot be scheduled, the showing of a motion picture would dramatize the assembly line techniques as they are applied to industry. Film titles relating to modern mass production are listed in subsequent chapters in this manual.

COURSE CONTENT

The metalworking course for the intermediate and junior high schools has been designed to provide students with broad experiences which will enable them to understand and appreciate the contributions being made by those employed in the field of metalworking. The activities and related information topics that are listed in this chapter indicate the broad scope of the program and have been selected because they constitute the basic operations, processes, and body of knowledge that are representative of the major areas within the metalworking industry.

IMPLEMENTATION

It is recommended that in implementing the program the teacher should strive to provide broad, exploratory experiences within each of the five major areas selected, rather than concentrate on one or two phases of metalwork. Orientation to the metalworking field is a basic purpose of the course. Therefore, students should be afforded the opportunity to sample a variety of operations within each of the major categories so that they can formulate concepts relating to important manufacturing processes and, at the same time, acquire new skills, knowledge, appreciations, and interests pertaining to metalworking and its related technologies.

Because the course content suggested on pages 28-33 is extensive (considering the amount of time allocated to the metalworking program during one school term), the teacher must use judgment in selecting topics for demonstrations and related information lessons. The teacher is given options to combine topics where relationships exist and must be flexible enough to gear the program to the level of those classes that are attending the metalworking shop.

It is important for the teacher to recognize that lessons which introduce each of the five major areas of metalworking be directed to the entire class and cover broad concepts. Follow-up lessons are presented, where needed, to smaller groups of students and are focused on more specialized topics.

The diversity of student backgrounds and abilities within each class makes it mandatory that the teacher use discretion in selecting topics for lessons. Careful consideration must be given not only to the relevancy of the topics to the objectives of the course, but also to their consistency with student abilities and needs.

ACTIVITIES

The learning activities that are enumerated within each of the five major metalworking areas constitute those operations and processes that can normally be executed in most metalworking shops in the intermediate schools. These activities are essentially the "doing" phase of the metalworking course which enables the student to understand concepts through the use of basic tools and machines. Single concept films and video tapes can provide the necessary reinforcement and review, and should be used wherever these teaching aids are available.

Preproduction Phase

In each of the five major areas that are studied, students can participate in the planning and preparation that is required prior to the fabrication of the metal product. Introducing research and development techniques, selecting designs, determining procedure, and considering economic factors enhance the course and

illustrate the relationship of planning and preparation to production and postproduction factors.

Production Phase

The activities listed under the category of "production" involve the use of tools and machines that permit the performance of operations and processes both in the making of the prototype (unit production) and the fabrication of multiple articles (mass production).

Postproduction Phase

Activities that pertain to the postproduction phase have not been itemized in the following pages devoted to the description of course content. To avoid repetition in each of the five major areas, postproduction activities that can be performed in the school are therefore mentioned here and are basically the same for all the areas taught. Activities in which students could participate, once the products were completed in the shop, would include:

Packaging product

Publicizing product

Distributing product: hospitals, charitable organizations

Selling product: P.A., G.O. store

Computing profit or loss

RELATED INFORMATION

Topics classified under Related Information provide the technical data and theoretical background that support the practical work performed in the metalworking shop. The subjects listed can be chosen as topics for related information lessons by the instructor; selected topics may be suitable for student research assignments which can be executed in the form of outside preparation reports.

Forming a hem on the bar folder

SAMPLE COURSE CONTENT PLANNING SHEET

Preproduction Phase

Activities *(Operations and Processes)*	**Related Information** *(Technical)*

Production Phase

Activities *(Operations and Processes)*	**Related Information** *(Technical)*

Postproduction Phase

COURSE CONTENT: SHEET METAL

Preproduction Phase

Activities *(Operations and Processes)*	Related Information *(Technical)*
Interpret a simple blueprint Estimate stock required for fabrication Identify and select sheet metals Read an operation sheet Make a bill of materials Compute cost of materials Use simple formulas: $D = 2 \times R$; $R = \frac{1}{2} D$; $C = \pi D$ Determine tool and equipment needs Develop a simple pattern Draw circles and arcs with compass and dividers Trace and enlarge by squares Use T square, drawing board, triangles Make a simple working drawing Add and subtract fractions Sketch decoration motifs Determine finishing techniques Draw parallel lines List sequential operations	Types and properties of sheet metal Sheet metal products in home and industry Relative costs of sheet stock Manufacture of sheet metals – tinplate, galvanized iron Plastics as substitutes for sheet metal Occupational information: sheet metal worker, draftsperson, designer, estimator, contractor Shop mathematics: fractions, formulas Geometric constructions: triangles, perpendicular Sheet metal vocabulary: parallel line development, seams, laps, hems, radial line development Elements of design Conservation of sheet metal materials Fabrication methods Research and development of sheet metal products Economics of marketing sheet metal products

Production Phase

Activities *(Operations and Processes)*	Related Information *(Technical)*
UNIT PRODUCTION Measure sheet metal: steel rule, wire gage, micrometer Lay out sheet metal: steel square, combination square, bevel protractor, dividers, prick punch, center punch, trammel points Transfer pattern to sheet metal: layout fluid, dye Cut sheet metal: straight snips, curved snips Punch sheet metal: solid, hollow, hand File sheet metal: flat file, half-round, round Form sheet metal: bar folder, cornice brake, box and pan brake, slip roll former, combination rotary machine, stake, anvil, vise Fasten sheet metal: rivets, self-tapping screws, nuts and bolts, solder, spot weld, joints, adhesives Finish sheet metal: polish, paint, lacquer, electroplate, anodize, galvanize, oxidize	Safety in the sheet metal area Sheet metal gage system: B. & S.; U.S.S. Layout methods: direct, template Hand and foot operated machines used in sheet metal operations Maximum thickness for machine use: bar folder, brake, squaring shears Solders and fluxes Types and sizes of fasteners Sheet metal joints: soldered, riveted, grooved Sheet metal decoration Finishing techniques Occupational information: sheet metal worker Riveting methods: rivet set, pop riveter Care of tools and equipment in sheet metal area
MASS PRODUCTION Trace templates Set stop gages: squaring shears, bar folder, brake Use bending fixtures Locate and drill with drilling fixture Operate power machinery: drill press Spot weld Spray surface Apply assemblyline methods	Punch and dies in manufacturing Industrial power machinery: power shears, punch press Soldering techniques in industry Occupational information: power press operator Riveting applications: airplane, subway car, truck Automation in the canning industry Standardization of sheet metal parts: automobile Industrial sheet metal bending

COURSE CONTENT: WROUGHT METAL

Preproduction Phase

Activities *(Operations and Processes)*	Related Information *(Technical)*
Read working drawing Enlarge sketches by the square method Calculate amount of metal needed for bends, scrolls, circles Compute cost of materials Plan operational procedure Make bill of materials Determine tools and equipment required for construction of product Identify and select wrought metals	Materials used in wrought metalwork Types and properties of metals Cost of strip, rod, bar, and other forms of metal used in wrought metalwork Wrought iron furniture: antique, contemporary Occupational information: ornamental wrought iron designer Elements of good design in wrought metalwork Wrought metal vocabulary: quenching, annealing, forging, tempering, hardening

Production Phase

Activities *(Operations and Processes)*	Related Information *(Technical)*
UNIT PRODUCTION	
Measure metal: steel rule, dividers, calipers, flexible rule Lay out metal: scriber, combination square, bevel protractor, dividers, center punch, layout fluid Cut metal: hacksaw, cold chisel, file Drill metal: twist drill, countersink, counterbore Form metal: vise, anvil, bending jig, bending fork Forge metal: tongs, furnace Heat treat metal: harden, anneal, temper Texture metal: ball peen, cross peen, straight peen Assemble metal: rivet, nut and bolt, screw thread, braze, weld Finish metal: undercoat, paint, lacquer, polish	Safety in the wrought metals area Hand tools used in wrought metalwork Types and sizes of files Occupational information: ornamental iron worker, structural iron worker, welder Decorating techniques in wrought metalwork Classification of hammers Parts of anvil Methods of fastening wrought iron components Strength of materials: ductility, brittleness, toughness, elasticity, malleability, tensile strength Testing hardness: file
MASS PRODUCTION	
Form in bending fixture Locate and drill holes with drilling fixtures Operate power machinery: drill press Spot weld Lay out shapes with template Apply assembly line techniques	Drop forging in industry: automobile crankshaft Power driven machinery: power press brakes, punch press Power driven tools for assembly: pneumatic wrenches, screwdrivers Brazing and welding in industry Quality control on the assembly line Testing hardness in the laboratory Carbon content of steels Industrial heat treating

COURSE CONTENT: JEWELRY AND ART METAL

Activities *(Operations and Processes)*	**Related Information** *(Technical)*
Develop design ideas for jewelry and art metal items Draw sketches Identify and select materials Compute cost of materials: metals, stones Determine tools and equipment Formulate operational sequence Read a working drawing Draw patterns Make a bill of materials	Metals used in jewelry and art metal work Relative cost of metals Stones: precious, semiprecious Occupational information: jewelry designer, silversmith Sources of designs History of jewelry and art metalwork Types of findings Fundamentals of good design Working properties of metals Jewelry and art metal vocabulary: piercing, planishing, pickling, chasing, peening

Production Phase

Activities *(Operations and Processes)*	**Related Information** *(Technical)*
UNIT PRODUCTION	Safety in the jewelry and art metal area
Lay out design: tempera, copper sulphate, layout dye, scriber, pattern, rubber cement	Jeweler's saw: nomenclature and sizes of saw blades
Cut metal: tinsnips, jewelers saw, squaring shears, pliers (wire), file	Classification of hammers
Form metal: bend, twist, raise, flute, flare, dome, draw, roll	Occupational information: jewelry repairer, ..., polisher
Join metal: soft solder, hard solder, rivet, epoxy	Wire sizes for braids and links
Clean metal: steel wool, emery cloth, pickle	Types of forming blocks
Decorate metal: chase, repousse, etch, enamel, engrave, peen, planish, stamp	Casting techniques in jewelrymaking
Heat metal: bunsen burner, propane torch, furnace	Grades of abrasives
Polish metal: hand buff, machine buff	Solders and fluxes used in jewelry and art metalwork
Finish metal: antique, lacquer, paint, plate, satin, anodize, matte	Types of glazes for enameling
Set stone: bezel, prong setting, wire	Cuts and shapes of stones
	Epoxy cements
	Melting points of metals
	Wire work in commercial jewelry
MASS PRODUCTION	
Cut metal blanks on squaring shears using stop gage	Manufacture of costume jewelry
Form metal on bending fixture	Automated deep drawing of metalware
Shape discs with hollow punch	Moving belt for finishing applications
Use power machines: drill press, buffer, flexible shaft machine	Stamping forms on power press
	Commercial jewelry casting

COURSE CONTENT: BENCH AND MACHINE METAL

Preproduction Phase

Activities *(Operations and Processes)*	**Related Information** *(Technical)*
Make a shop sketch Interpret a working drawing Identify and select metals Make a bill of materials Calculate cost of materials Determine operations sequence	Materials used in bench and machine metalwork Properties of metals Cost of materials Occupational information: machine draftsperson, tool designer, product designer, manufacturing engineer Tolerance in machine work Applications of bench and machine work Vocabulary in bench and machine work: lathe, chuck, surface plate, spindle, clearance, cutting speed

Production Phase

Activities *(Operations and Processes)*	**Related Information** *(Technical)*
UNIT PRODUCTION	
Measure metal: steel rule, calipers, combination square, micrometer Lay out metal: scriber, center punch, dividers, combination square, center head, bevel protractor Cut metal: (hand) hacksaw, cold chisel, file Cut metal: (machine) lathe, miller, power hacksaw Drill metal: (hand) hand drill, twist drill Drill metal: (machine) drill press, lathe, countersink, counterbore Thread metal: tap, die Form metal: bend, forge Heat treat metal: harden, anneal, temper, case harden Finish metal: polish, paint, lacquer Assemble metal parts: screw driver, wrench	Safety in the bench and machine area Tools used in layout Classification of files Drill sizes Occupational information: bench worker, machine operator, machinist, tool and die maker, inspector Basic machine operations: lathe, drill press, miller, shaper, planer, grinder, band and hack saws Care and maintenance of machines Applications of screw threads Machine feeds and speeds Cutting tool design factors Transmission of power: gears, threads, pulleys Classification of abrasives Types and sizes of fasteners
MASS PRODUCTION	
Use power machines: lathe miller, drill press, grinder Use drilling fixture Assemble parts in locating fixture Use assembly line techniques Check size with gages: go, no-go Use injection molder for plastics components	Automation and numerical control Special machining processes: electrical discharge, powder metallurgy Automatic screw machines Quality control: gages, comparators Interchangeability of parts Subcontracting machine work Metal molds for plastics processing

COURSE CONTENT: CAST METAL

Preproduction Phase

Activities *(Operations and Processes)*	**Related Information** *(Technical)*
Design one piece pattern Construct pattern: wood, metal, styrofoam Read working drawing Select casting material Determine melting temperature Compute cost of metal to be cast Plan operational procedure Prepare tools and equipment required for casting	Types of metals used in foundry Properties of casting metals Melting temperatures of metals Sources of raw materials Occupational information: pattern maker, product designer, metallurgist Foundry vocabulary: draft, shrinkage, flask, riddle Applications of castings Composition of alloys

Production Phase

Activities *(Operations and Processes)*	**Related Information** *(Technical)*
UNIT PRODUCTION	
Riddle sand Temper sand Select and prepare flask Make a sand mold for a one piece pattern Vent mold Form sprue Cut gates Pour metal in mold Shake out casting Trim and clean casting Finish casting	Safety in the cast metals area Foundry equipment Sand used in molding Shrinkage and the shrinkage rule Types of pattern construction: one piece, split Occupational information: foundry technician, molder Conservation of metals: remelting scrap metal Historical development of casting process Machining a casting: finishing to specifications Casting processes: centrifugal casting, lost wax method
MASS PRODUCTION	
Use match plate to cast multiple units Apply assembly line techniques to clean and finish castings	Automation in the foundry Automatic mixers Moving belts to transport flasks Die casting in industry

SHEET METAL

The importance of the sheet metal industry is manifested by the diversity and number of products that are manufactured from thin gage metals. The transportation industry's use of sheet metal in the construction of vehicles is just one example of the popularity of sheet metal as a covering medium. Bodies for automobiles, trucks, trailers, buses, trains, and airplanes attest to the wide application of such sheet materials as steel and aluminum. The use of sheet metal in the form of containers, tin cans or steel drums, and the innumerable products ranging from aerospace vehicles to washing machines provide ample evidence of the versatility of this form of metal.

In the industrial arts metalworking shop, the student takes advantage of a unique characteristic that is recognized and used by the sheet metal industry, namely, the property of the metal to be cut and bent easily and then retain its shape after bending. Another advantage which favors the use of sheet metal is its ability to be joined easily by such methods as riveting, soldering, or welding.

Several concepts relating to sheet metal — the material and the processes by which it is formed into functional products — can be taught. Students must visualize how a flat metal sheet can be transformed into a three dimensional shape. They must necessarily plan ahead by considering allowances for bending, hems, and joints. They must also prepare a pattern or execute a careful layout directly on the surface of the metal prior to cutting and bending.

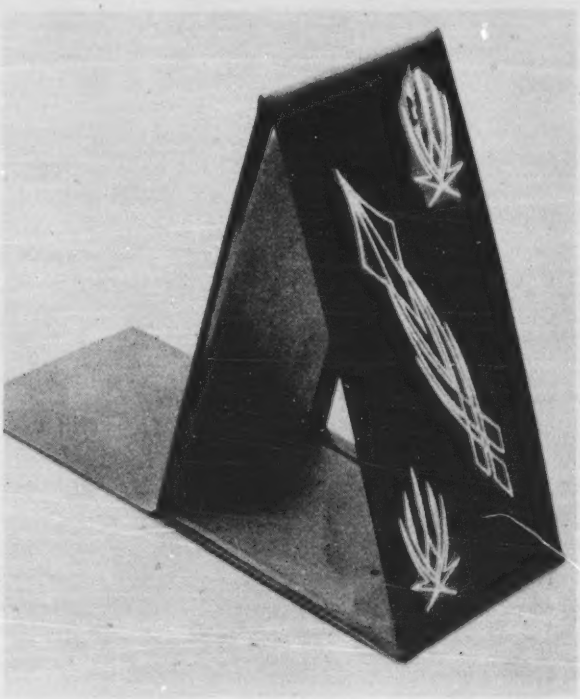
Students should be aware that those people who work with sheet metal to earn their living are not necessarily sheet metal workers. For example, power press operators who perform specialized operations on a mass production basis would be classified as machine operators. Their responsibility would entail stamping out flat metal sheets into parts that range from housings for refrigerators to bodies for trucks and buses.

In contrast to the machine operator is the sheet metal worker who builds *to order*. This job title calls for a broad background of knowledge and experience with tools, materials, and machines relating to the fabrication and installation of metal products. This type of skilled worker is found not only in the aircraft, automotive, and ship building industries, but also in those dealing with air conditioning, heating and ventilation.

The sheet metal area in the school shop can illustrate these two sheet metal work categories: the fabrication of custom-made units and the mass production of sheet metal parts. In the unit production activity (custom-made approach), each student can develop and construct the single item with the use of those tools and machines required for producing a custom-made part from sheet metal. Experimentation in mass production approaches can be readily undertaken by the application of labor-saving techniques: use of stops on the squaring shears; utilization of bending fixtures and drilling jigs; and assembly fixtures for spot welding. Further techniques include the use of punches and pop riveters which are easily adaptable to assembly line methods in the school shop.

This suggested unit production activity offers individual participation by each student in the use of hand and machine tools in the sheet metal area. To conserve time and expedite the distribution of metal, strips can be precut to 3½" x 20¼" which will allow the student to trim the metal to the specified length. Use of a template or the direct layout method can be determined by the teacher. While the basic shape is uniform for the entire class, a variety of finishes and decorating techniques can be applied.

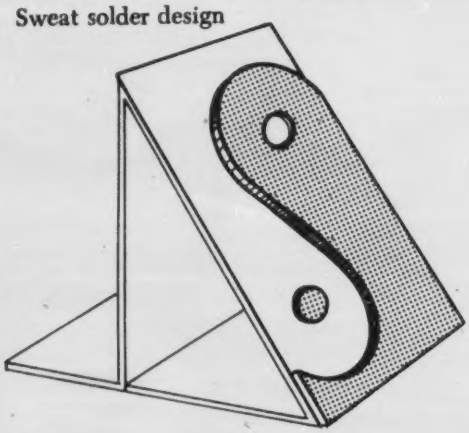
It should be noted that if this product were manufactured commercially, it could be conveniently shipped from the factory in flat form as a *prefab* item. The customer, by following printed instructions, could fold and assemble the material so that the resulting book ends would be ready for use.



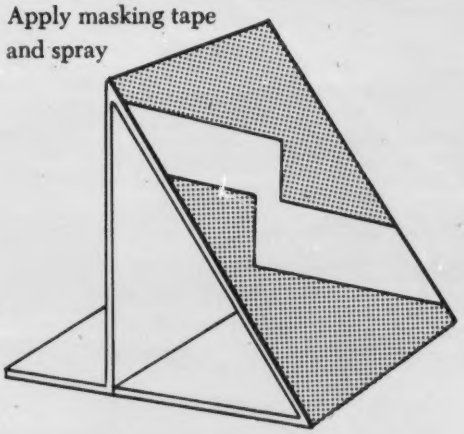
Surface decoration on book end

BOOK ENDS: Decorating Techniques

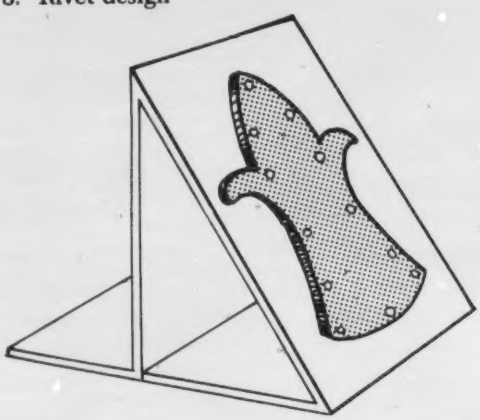
1. Sweat solder design



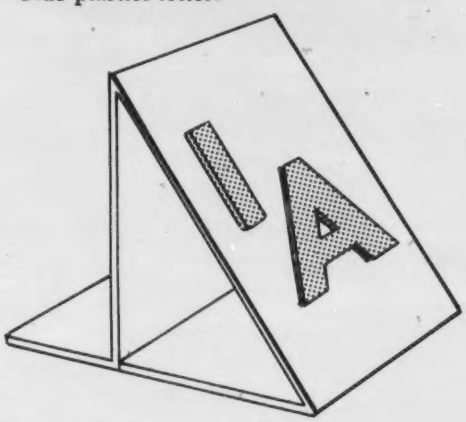
2. Apply masking tape and spray



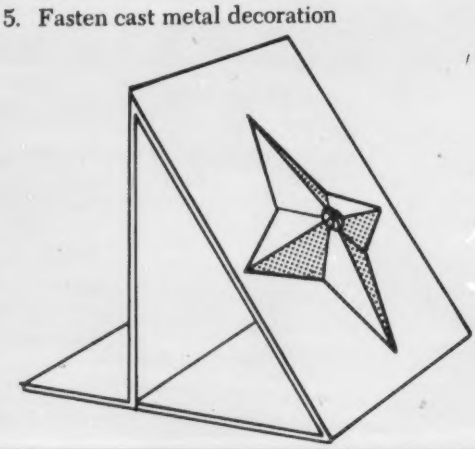
3. Rivet design



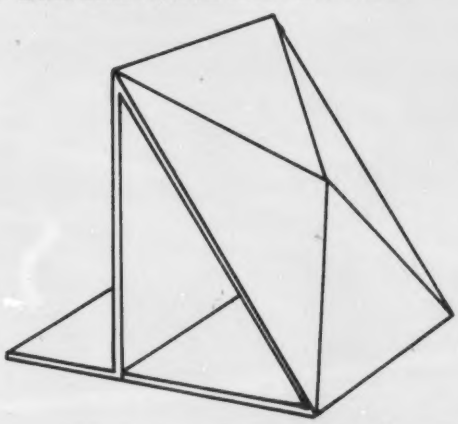
4. Glue plastics letters



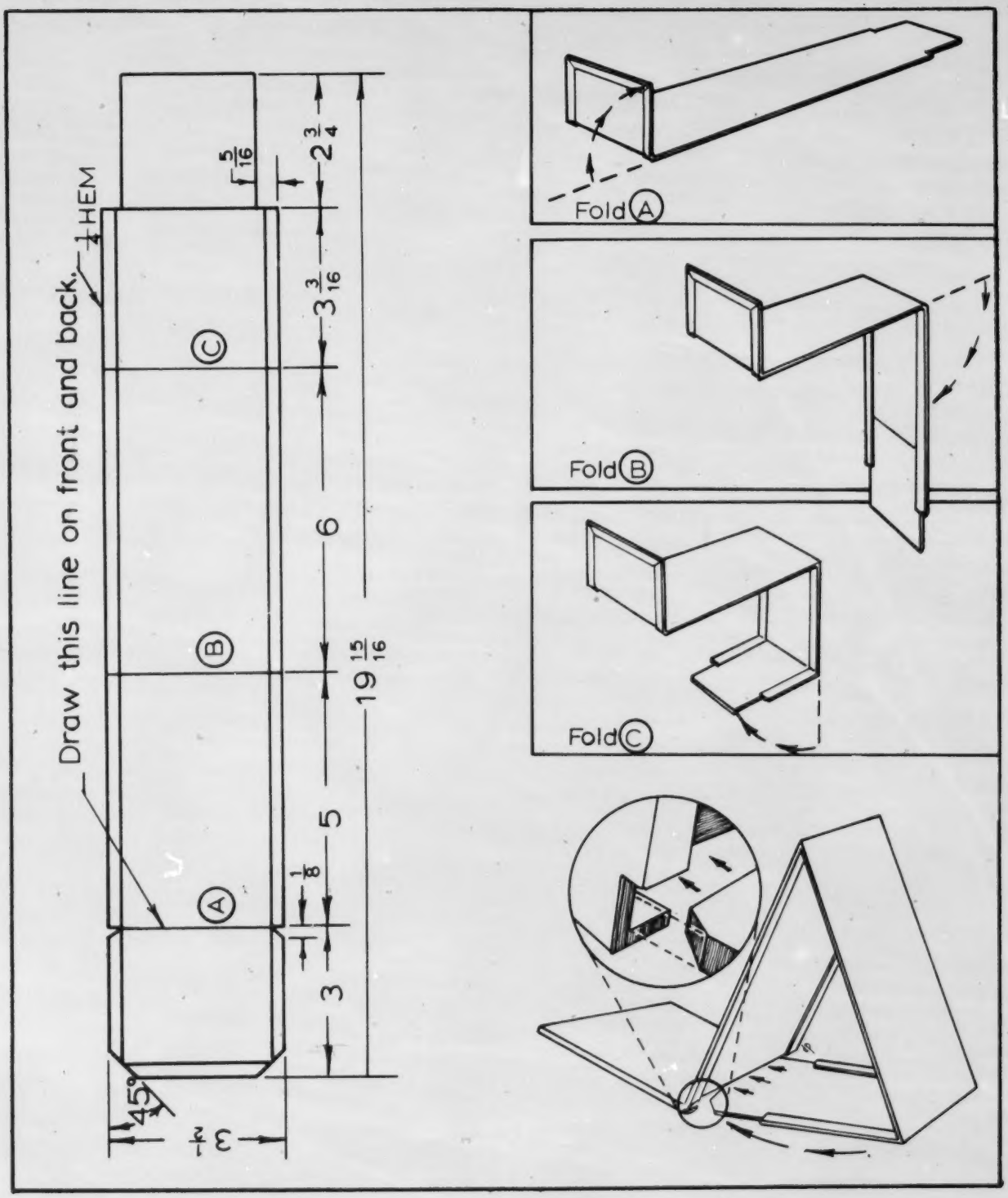
5. Fasten cast metal decoration



6. Bend metal to form decorative crease



BOOK ENDS: Layout and Folding Sequence



OPERATION SHEET

BOOK ENDS

Sequence	Operation Description	Tools and Equipment
1	Lay out and cut strip to 19 15/16" length	Steel rule, combination square, tinner snips, scratch awl
2	Lay out lines for hems, notches and bends.	Rule, scratch awl, combination square
3	Cut notches, miter corners and cut out as per drawing. Remove burrs.	Tinners snips, file
4	Fold (3) ¼" safety hems. Avoid sealing completely those hems that are located to the left of symbol *A* as designated on drawing. (Use a removable sheet metal spacer)	Bar folder, sheet metal spacer
5	Fold bends at *A*, *B*, and *C* as designated on drawing (All bends are right angle, 90 degrees to edge)	Box and pan brake
6	Slide tab under unsealed hems	
7	Lock tab in place by *dimpling* with center punch on steel block	Ball peen hammer, steel block, center punch
8	Clean work with steel wool (Safety: Be careful of sharp edges of product and wool itself)	Steel wool
9	Decorate with paint	Masking tape, spray paint
10	Apply protective covering on base	Felt or flocking, slip-resistant covering

14

DEMONSTRATION LESSON PLAN

Topic: Cutting Sheet Metal

Aim: To introduce concepts and techniques relating to the cutting of thin gage metals in the school shop and industry.

Preparation:

Straight tin snips	Hacksaw	Vise
Aviation snips	Hollow punch	Sheet metal stock
Cold chisel	Ball peen hammer	Scrap wood
Nibbler		

Visual Aids:

Samples of mass produced sheet metal parts: laminations
Photographs of industrial machines: power shears, power punch press

Motivation:

Cut sheet metal with straight tin snips; squaring shears
Note advantages and disadvantages of both methods

Presentation:

1. Demonstrate a variety of cutting techniques using snips, punch, and chisel
2. Discuss other methods: squaring shears, ring and circle shears
3. Correlate simple machine principles: wedge, lever (mechanical advantage). Power sources: hand, foot, electrical, hydraulic
4. STRESS SAFETY: FINGERS AWAY FROM CUTTING EDGES, SHARP EDGES (BURRS) METAL THICKNESS (MAXIMUM GAGE PERMITTED)
5. Note conservation of materials: maximum use of materials; minimum waste
6. Industrial Relationship: Compare shop tools and machines with industrial sheet metal cutting equipment. Mention power driven machines: power shears, power punches. Show photographs and samples of cut shapes.

Summary:

Review school shop and industrial types of sheet metal cutting equipment.
Stress safety precautions.

Application:

Students cut sheet metal during construction of the book ends, or for other introductory sheet metal activities.

Assignment:

Collect ten photographs or advertisements (possibly from newspapers or magazines) that depict examples of commercially produced sheet metal products requiring one or more of the methods described in the lesson.

References:

Feirer, J.L. and Lindbeck, John R. I.A. Metalwork. Unit 9, "Cutting Thin Metal," pp. 44-49.
Ludwig, O.A. and McCarthy, W.J. Metalwork Technology and Practice. Unit 39, "Sheet Metalwork, Hand Tools, and Cutting Tools," pp. 295-309.

RELATED LESSON PLAN

Topic: Fastening Sheet Metal

Aim: To introduce concepts relating to the methods of fastening sheet metal in the school shop and industry.

Preparation:

Rivets — Sheet metal screws — Sheet metal seams
Solder — Spot weld — Adhesive (Epoxies)
Photographs of industrial equipment used for fastening purposes
Photographs of the various applications of fastening procedures.

Motivation:

How does the tin can prevent liquids from leaking and air from entering?
How are the parts of the tin can fastened?

Presentation:

1. Exhibit samples of sheet metal specimens that have been fastened together by such methods--soldering, spot welding, riveting, sheet metal screws.
2. Discuss advantages and disadvantages of each method--speed of operations, cost of materials, interchangeability of parts, availability of equipment, skill required, and safety hazards.
3. Display photographs depicting application of fastening techniques -- subway car, airplane, rocket, and other products.
4. Industrial Relationship. Compare tools and machines in shop with sheet metal fastening equipment in industry. Mention air hammer, gang spot welder, power driven riveter, pneumatically driven screwdriver.

Summary:

Review methods of fastening sheet metal parts.
Enumerate advantages and disadvantages of each technique.

Application:

Students fasten section of book end to base by means of a sheet metal joint.

Assignment:

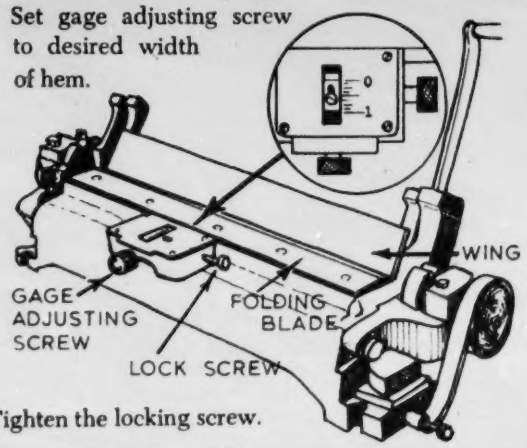
List ten sheet metal products that utilize one or more methods of fastening that were described. Indicate the method of fastening for each item named.

References:

Feirer, J.S. and Lindbeck, John R. I.A. Metalwork. Unit 25, "Fastening Sheet Metal," pp. 113-116.
Johnson, Harold V. Technical Metals. Unit 52, "Fastening Sheet Metal," pp. 198-201.

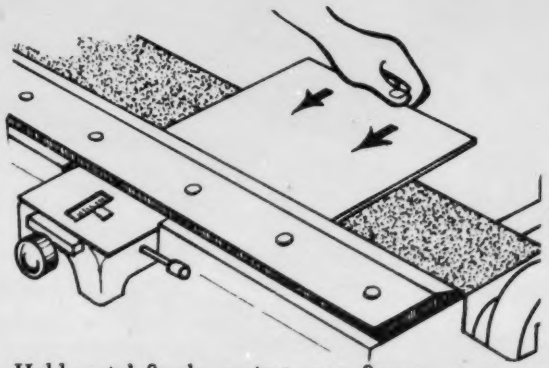
FORMING A HEM ON THE BAR FOLDER: Sample Instruction Sheet

1. Set gage adjusting screw to desired width of hem.



Tighten the locking screw.

2. Insert edge of metal under the folding blade.

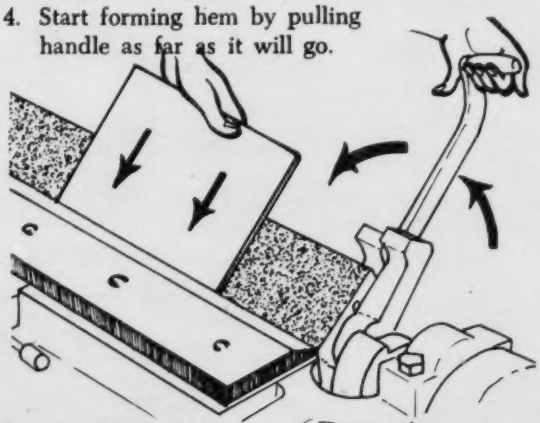


Hold metal firmly against gage fingers.

3. Place right hand on handle of bar folder.

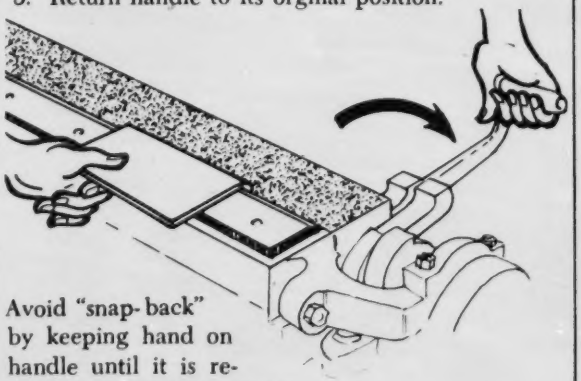
Maintain pressure of metal against gage fingers.

4. Start forming hem by pulling handle as far as it will go.



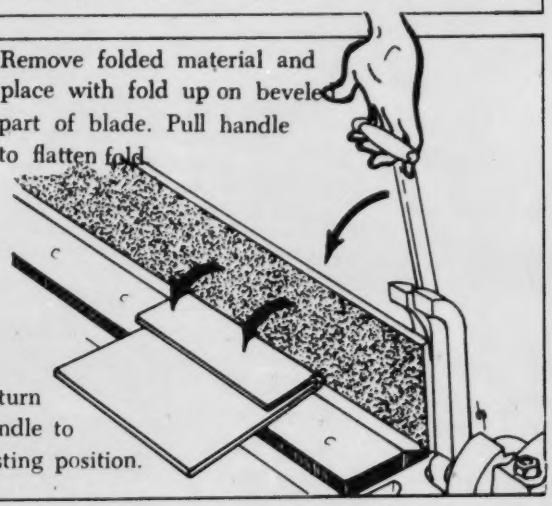
SAFETY: KEEP LEFT HAND CLEAR OF WING.

5. Return handle to its orginal position.



Avoid "snap-back" by keeping hand on handle until it is returned to its resting position.

6. Remove folded material and place with fold up on beveled part of blade. Pull handle to flatten fold.

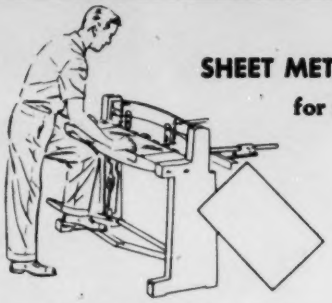


Return handle to resting position.

47

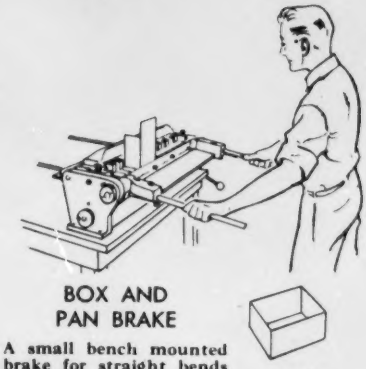
SHEET METAL WORKING MACHINERY APPLICATION

for schools, shops and general industries



SQUARING SHEARS

Used for trimming and squaring sheet metal.



BOX AND PAN BRAKE

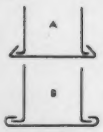
A small bench mounted brake for straight bends up to full length of machine or for box and pan work up to 3 inch depth.

A—This shows how bottom edge of body, and bottom of Can are prepared by Burring Machine for Setting-Down.

B—The Pexto Setting-Down Machine closes the seam, as shown here. It works both speedily and accurately.

SETTING DOWN MACHINE

The Setting Down Machine prepares the seams in body of vessels for double seaming



NOTCHER, COPER AND SHEAR

Combination machine for small, diversified jobs.

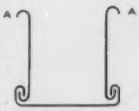
AA—Showing edges turned by Pexto Burring Machine. Note right-angle burr on body of can, and a still more pronounced burr on the bottom piece. The edge on bottom is turned smaller than on the body.

BURRING MACHINE

A difficult operation to master but practice will produce uniform flanges on sheet metal bodies. Prepares the burr for bottoms preparatory to setting down and double seaming.

TURNING MACHINE

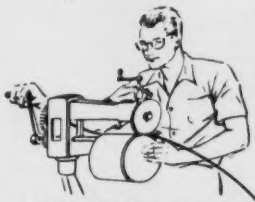
Used to prepare a seat in bodies to receive a wire. The operation is completed with use of Wiring Machine.



AA -Seats for Wire—made on the Turning Machine.

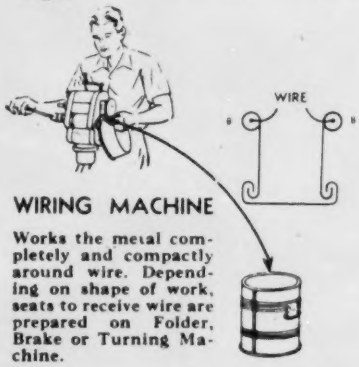
FOLDING MACHINE

The Folding Machine is used extensively for edging sheet metal or the forming of locks or angles.



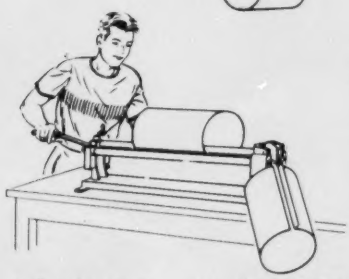
DOUBLING SEAMING MACHINE

Offered in various styles and follows the setting down operation.



WIRING MACHINE

Works the metal completely and compactly around wire. Depending on shape of work, seats to receive wire are prepared on Folder, Brake or Turning Machine.



FORMING MACHINES

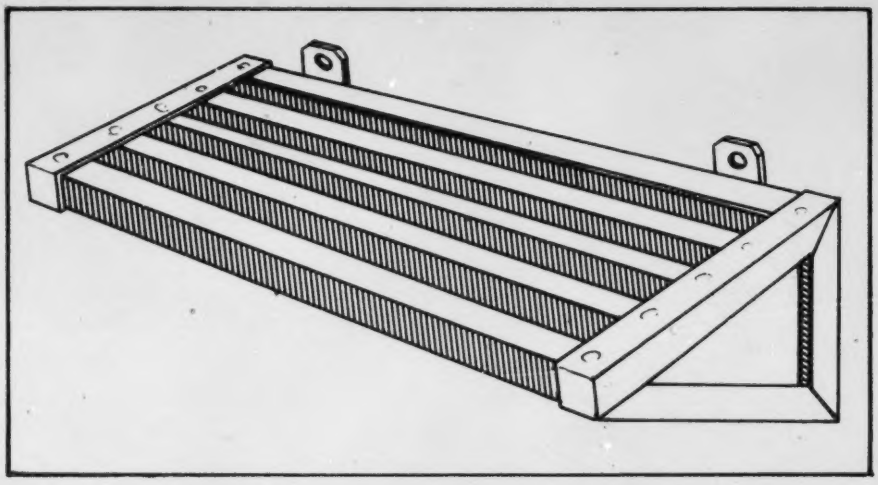
Used for forming flat sheets into cylinders of various diameters such as stove pipe, the bodies of vessels, cans, etc. Made in a variety of sizes and capacities.

BEADING MACHINE

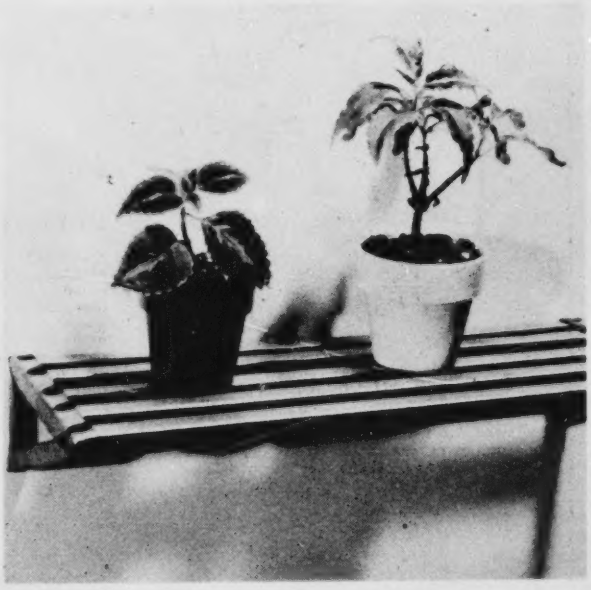
For ornamenting and stiffening sheet metal bodies.

Courtesy of Peck, Stow & Wilcox Co.

MASS PRODUCTION: SHEET METAL
PRODUCT: Utility Shelf



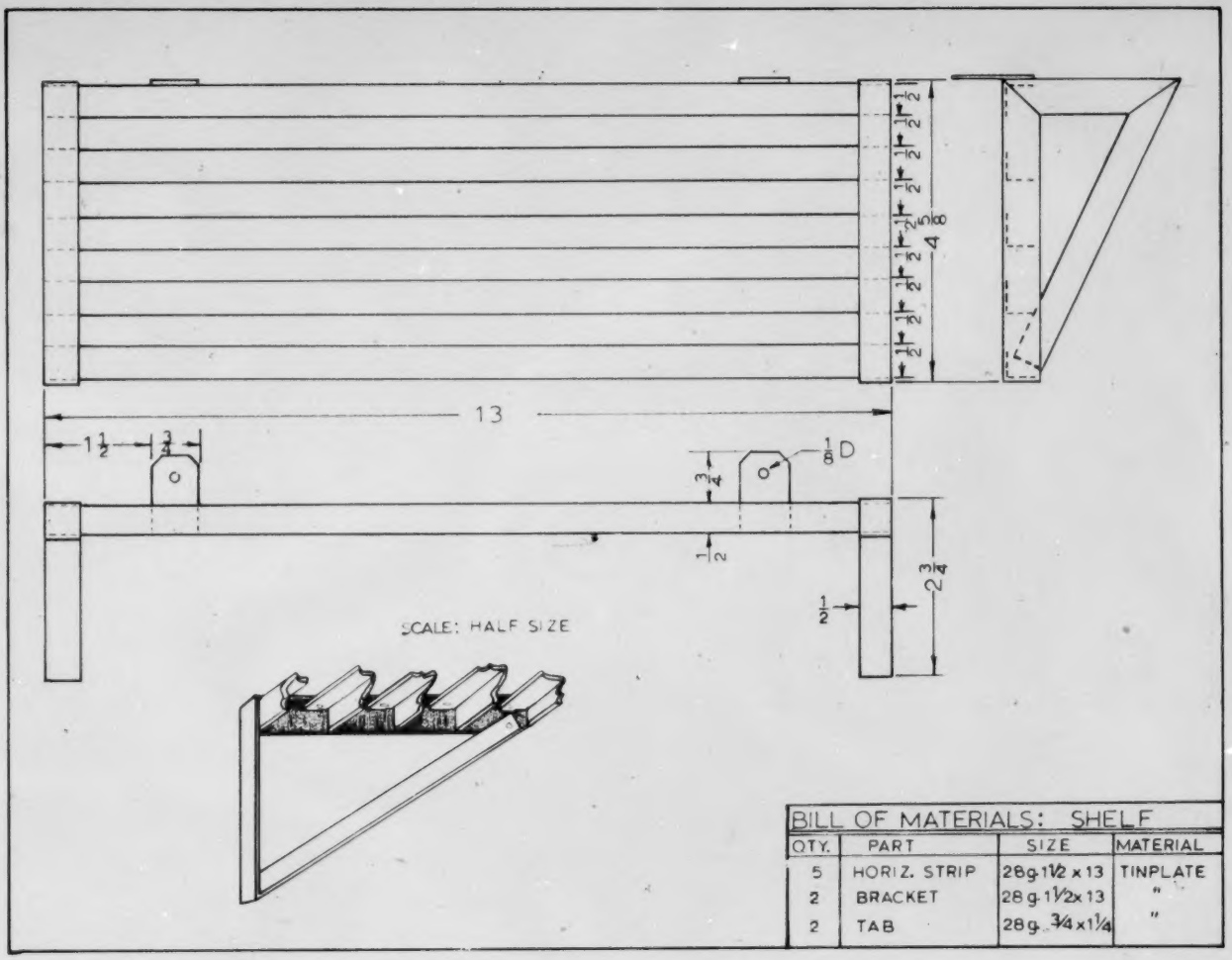
This useful and attractive product can be readily fabricated on a mass production basis. The finished article can serve as a shelf for holding a transistor radio, books or small knickknacks. The product can also function as a spice rack in the kitchen. Because there are several locations within the home where the shelf would be handy, this product has excellent salable potential at the school industrial arts fair, G.O. bookstore or Parents' Association functions.



Design modifications will permit the replacement of the horizontal sheet metal inserts with perforated steel or aluminum sheet which can be obtained in a variety of patterns. Wood can also be substituted for the horizontal cross pieces. Mounting holes for the shelf may be drilled or punched directly through the frame, or mounting tabs may be welded into position. Further changes can be made by varying the length of the shelf according to the needs and the desires of the students responsible for product planning. Spraying the product with enamel or adding a decorative wood or sheet metal backboard affords additional opportunities for product design changes.

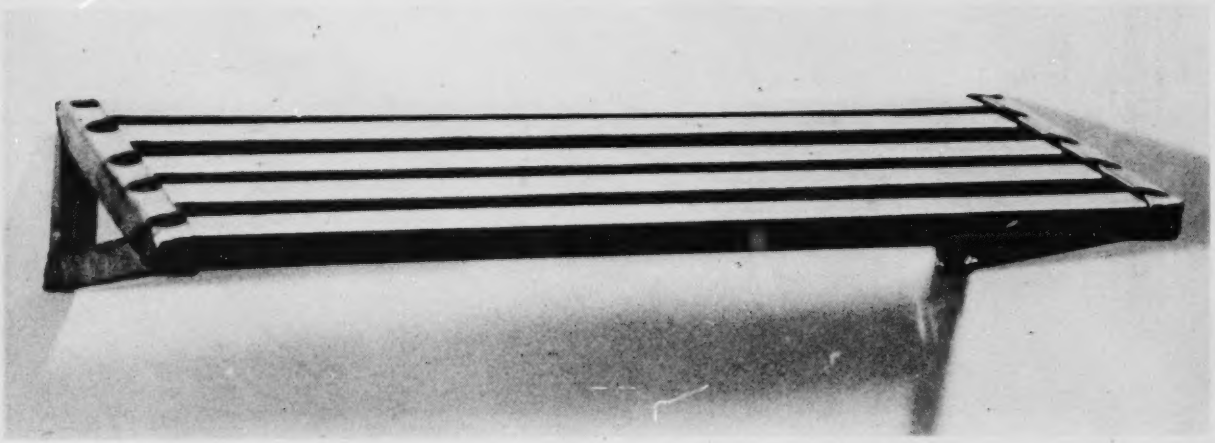
From the standpoint of mass production and the interchangeability of parts, this product offers an important advantage, namely, that most of the components can be cut to the same length and folded to the same cross-sectional profile. While the operation sheet specifies that the product is assembled by spot welding, sweat soldering can be used as an alternate method.

UTILITY SHELF: Bracket Layout

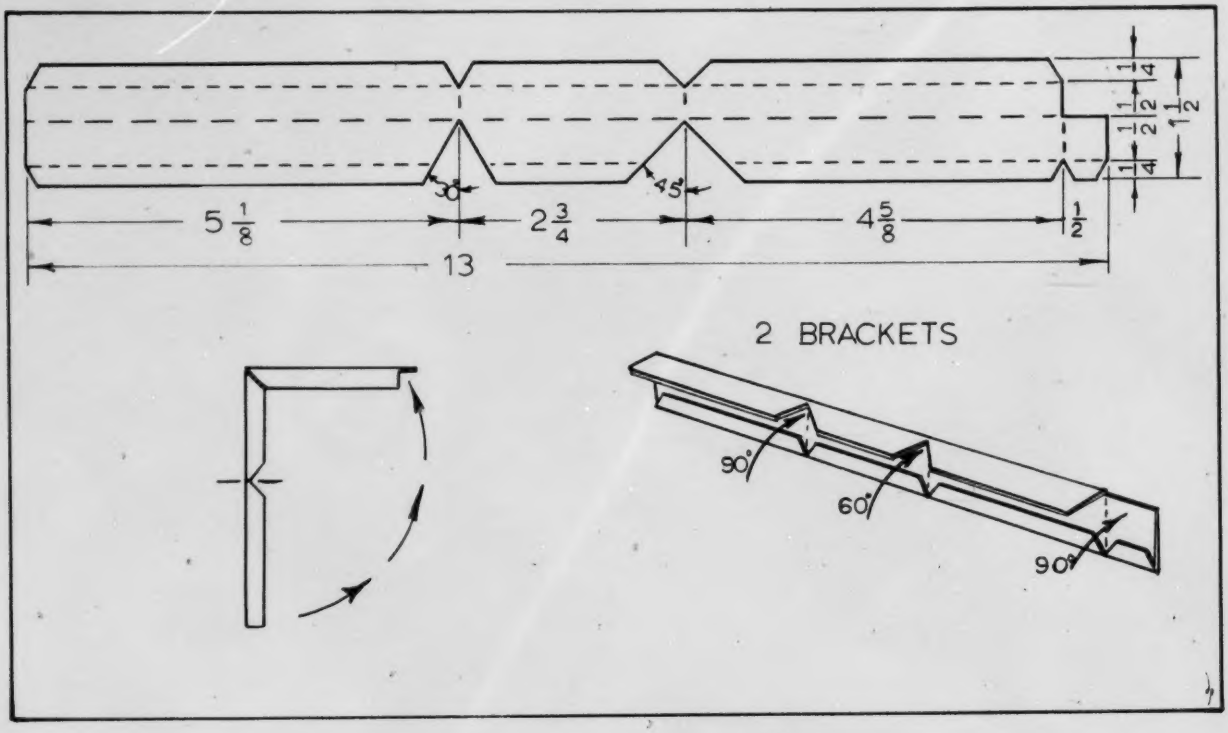


BILL OF MATERIALS: SHELF

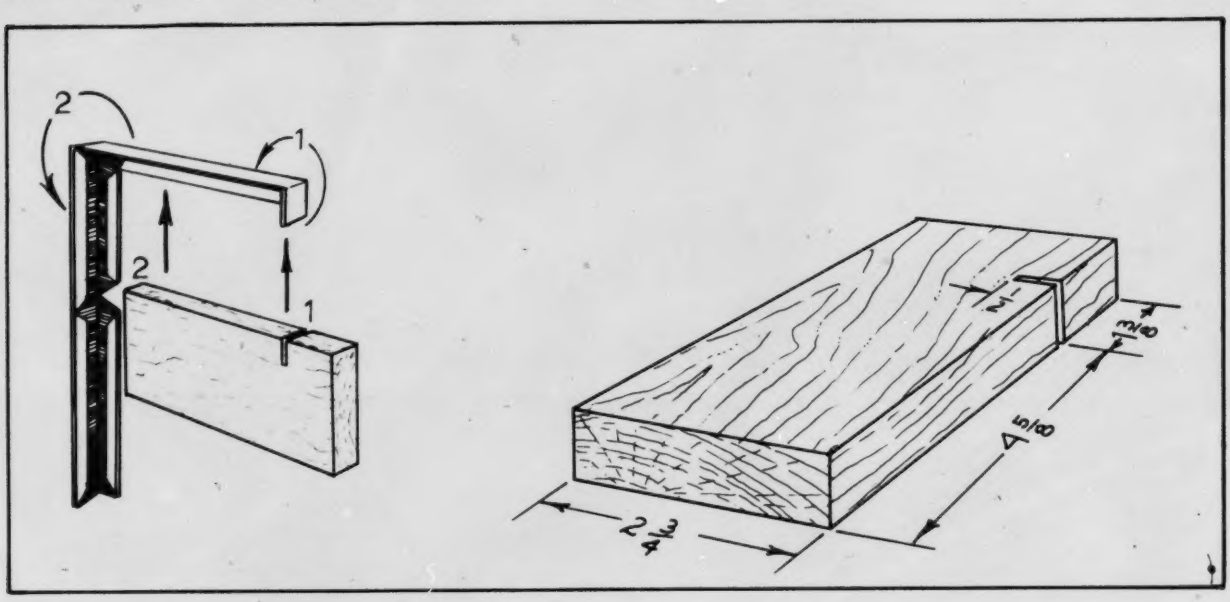
QTY.	PART	SIZE	MATERIAL
5	HORIZ. STRIP	28g. 1½ x 13	TINPLATE
2	BRACKET	28g. 1½ x 13	"
2	TAB	28g. ¾ x 1¼	"



UTILITY SHELF: Bracket Layout



UTILITY SHELF: Bending Fixture (Bracket)



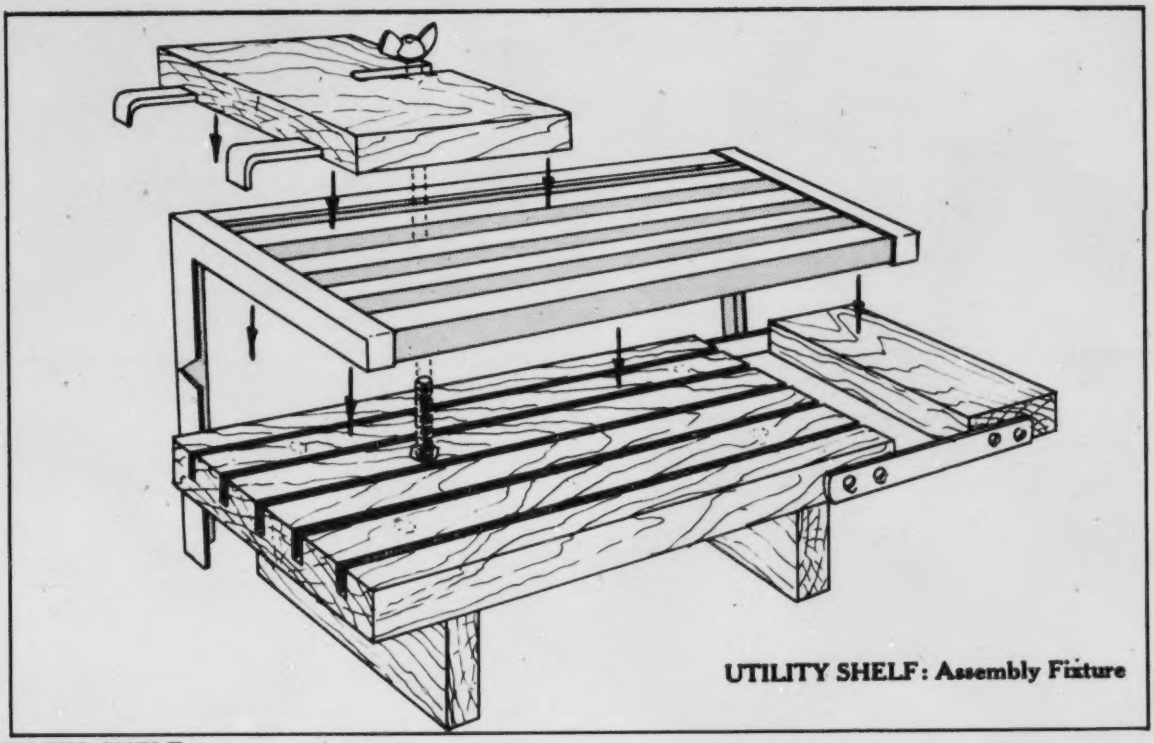
OPERATION SHEET

UTILITY SHELF

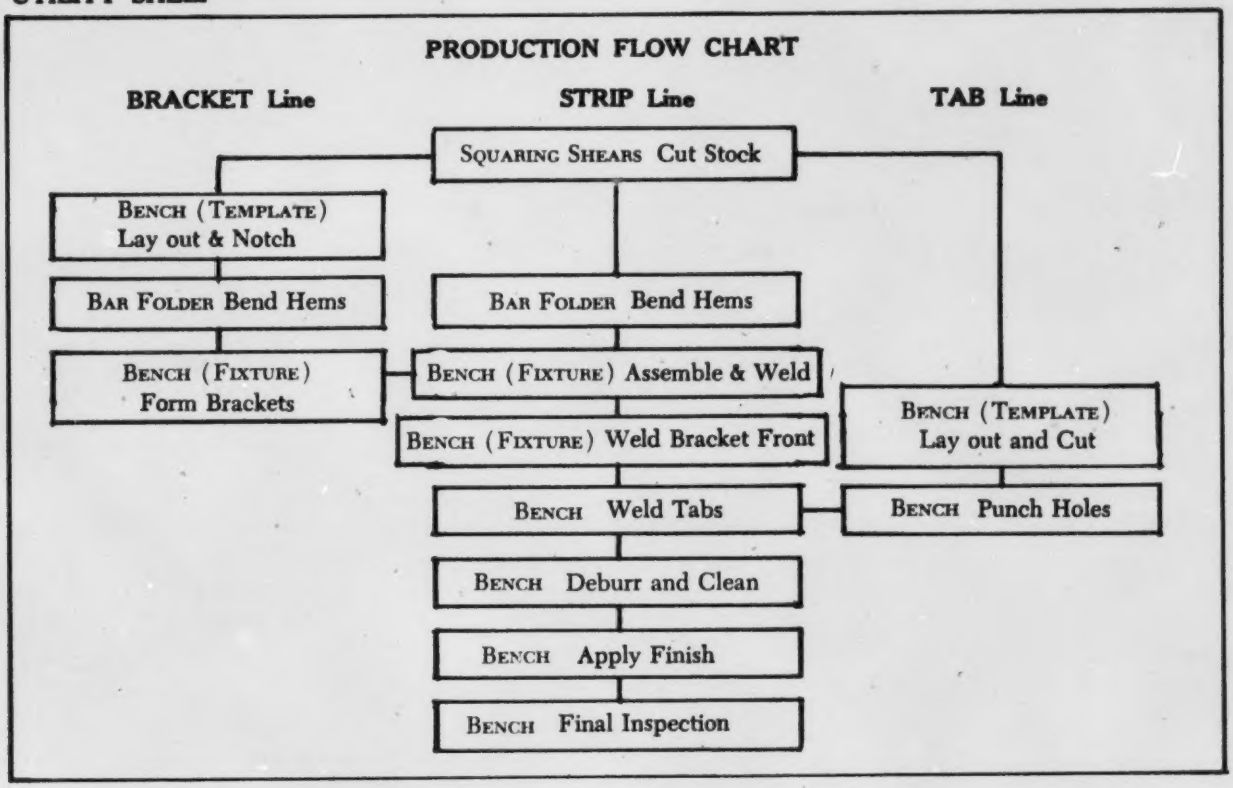
Sequence	Operation Description	Tools and Equipment
1	Set back gage on squaring shears to 13" and cut sheet metal to length	Steel rule, squaring shears
2	Reset gage to 1½" and cut strips to proper width. Also cut tabs 1½" square. (One per unit needed.)	Steel rule, squaring shears
3	Select two strips for bracket sections for each unit. Lay out notch area.	Template, scriber
4	Cut notch areas. Remove slivers or burrs.	Tinsnips, file, emery cloth
5	Make ¼" safety hems for horizontal strips	Bar folder
6	Make ¼" safety hems for bracket. Hems are bent in opposite directions to make left and right-hand brackets.	Bar folder
7	Adjust bar folder for ½" – 90 degree bend. Bend all strips.	Bar folder
8	Form side brackets in bending fixture. Make right and left-hand brackets.	Bending fixture
9	Locate components in final assembly fixture. Clamp parts securely.	Assembly fixture
10	Spot weld all joints on top portion of shelf	Spot welder
11	Remove unit from assembly fixture and locate in bracket welding fixture. Spot weld.	Bracket welding fixture, spot welder
12	Remove unit from bracket welding fixture. Insert mounting tabs. Weld.	Spot welder
13	Remove burrs and sharp edges	File, emery cloth
14	Clean project	Steel wool
15	Apply finish	Spray
16	Final Inspection	

CONSTRUCTION of TABS

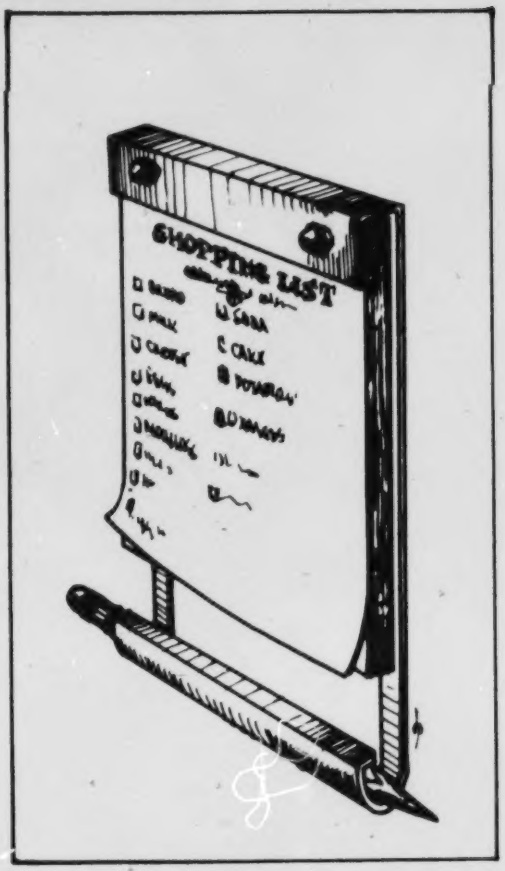
1	Cut tab material to length using back gage as stop	Squaring shears, steel rule
2	Place template on 1½" square tab blank and lay out for diagonal cut and holes	Template, scriber
3	Make diagonal cut	Tinsnips
4	Punch holes	Whitney punch



UTILITY SHELF

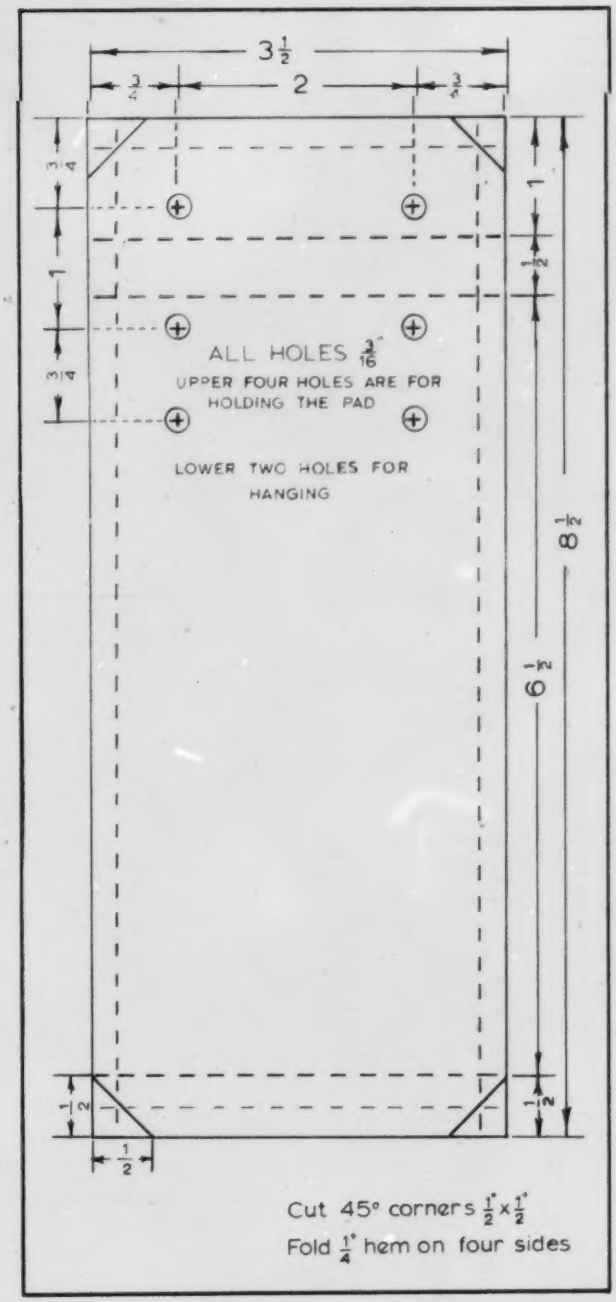


MASS PRODUCTION: SHEET METAL
PRODUCT: Shopping List Holder

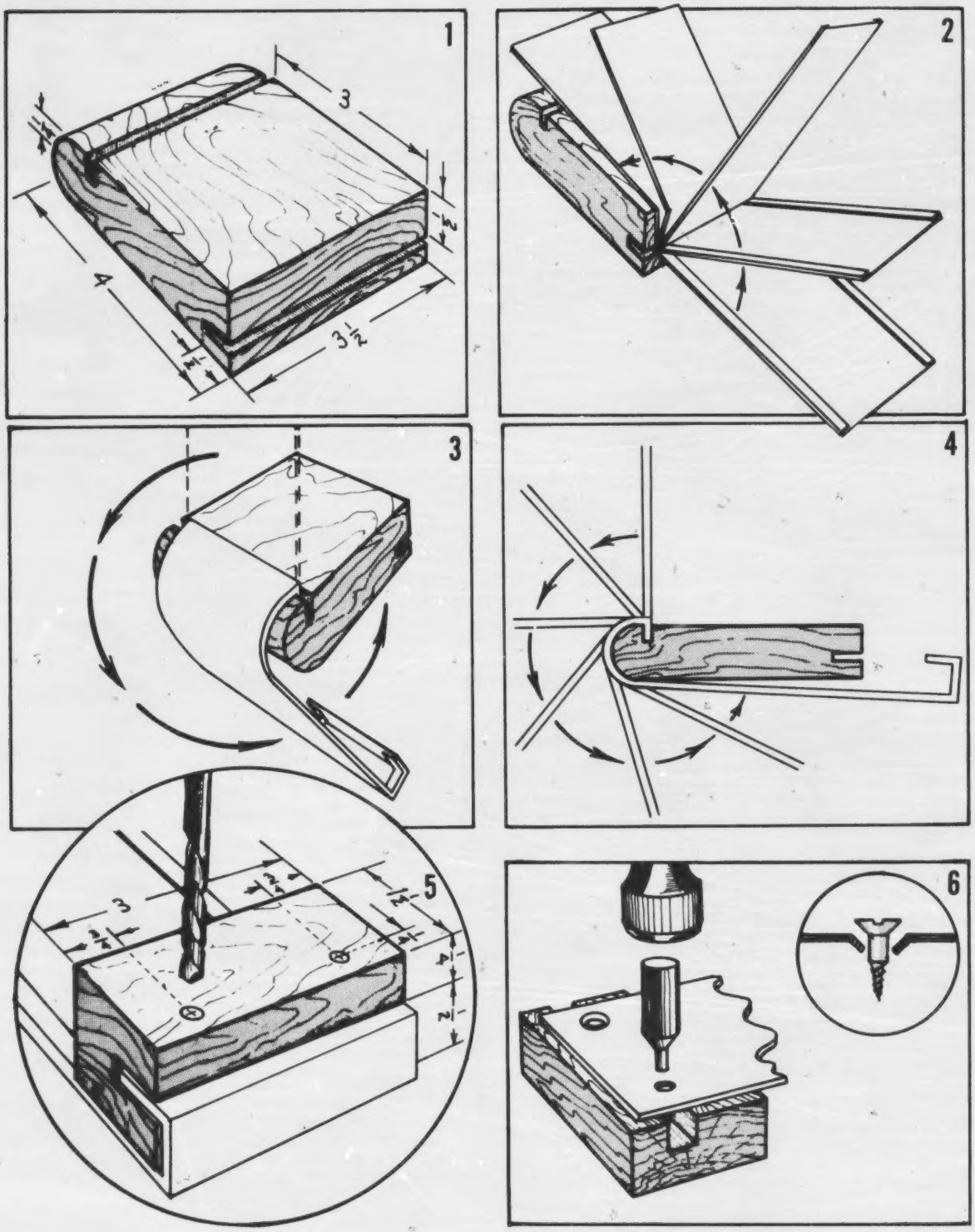


The shopping list holder constructed from aluminum sheet can serve as an alternate mass production article that has practical value in the home. Printed itemized paper fillers will enhance this product and can be supplied by the graphic arts shop which can serve as the subcontracting agency. With the cooperation of the graphic arts instructor, itemized sheets can be printed and holes may be punched or drilled according to specifications. The printed forms can then be delivered to the metalworking shop where the sheets can be inserted in the holder during the assembly operation as indicated on the production flow chart.

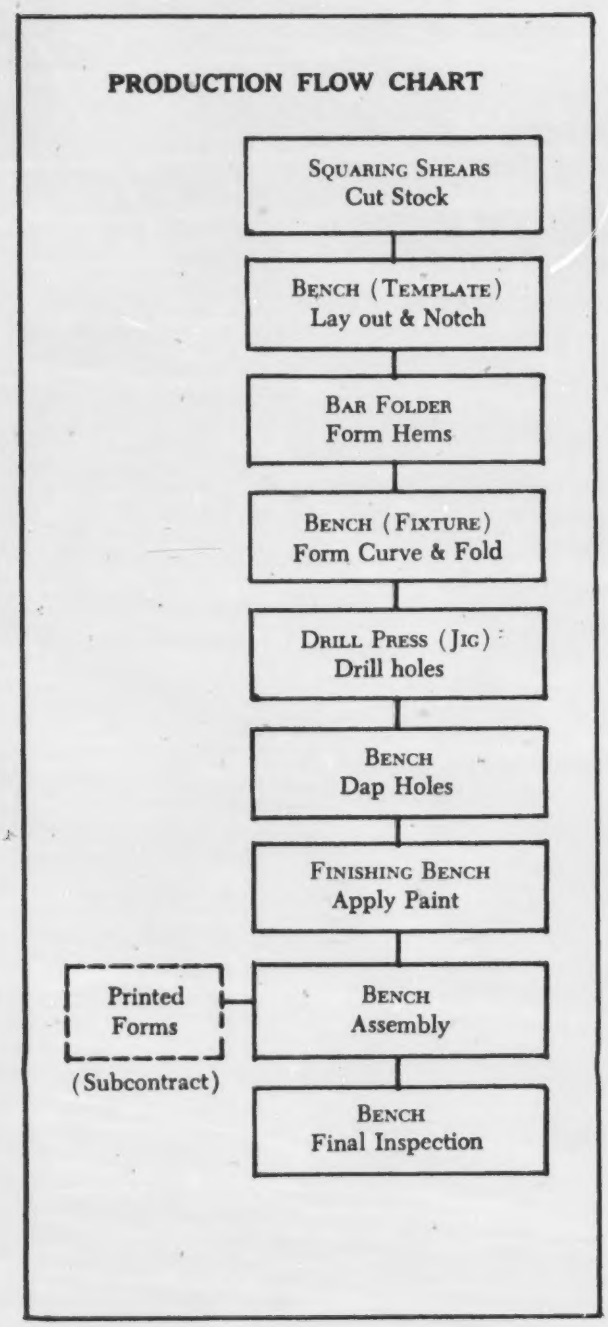
SHOPPING LIST HOLDER: Layout



SHOPPING LIST HOLDER: Bending and Drilling Fixture



SHOPPING LIST HOLDER



OCCUPATIONAL INFORMATION: Sheet Metal

SHEET METAL WORKER

TYPE OF EMPLOYMENT: The sheet metal worker fabricates and installs a wide variety of products that are made from thin metal sheets. This skilled worker should not be confused with the assembly line factory employee, such as the punch press operator, who also makes sheet metal products and who has limited knowledge and skills relating to a few specific operations.

In the heating or air conditioning field, the sheet metal worker must be familiar with all aspects of the trade. The sheet metal worker lays out and plans the job, determining the size and type of sheet metal to be used. This worker will fabricate the ducts in the sheet metal shop while working with tools and machines to cut, bend, shape and join various sheet metal components.

WHERE EMPLOYED: The sheet metal worker who performs construction-related work will be employed mainly by companies that fabricate and install heating, refrigeration, and air conditioning equipment and by contractors who are engaged in residential, industrial, and commercial building work.

The sheet metal worker who is employed in nonconstruction industries will be found in the railroad, aircraft, or shipbuilding industries. In addition, small shops manufacturing specialty products such as custom kitchen equipment for homes, hotels, and restaurants, require the help of the sheet metal worker.

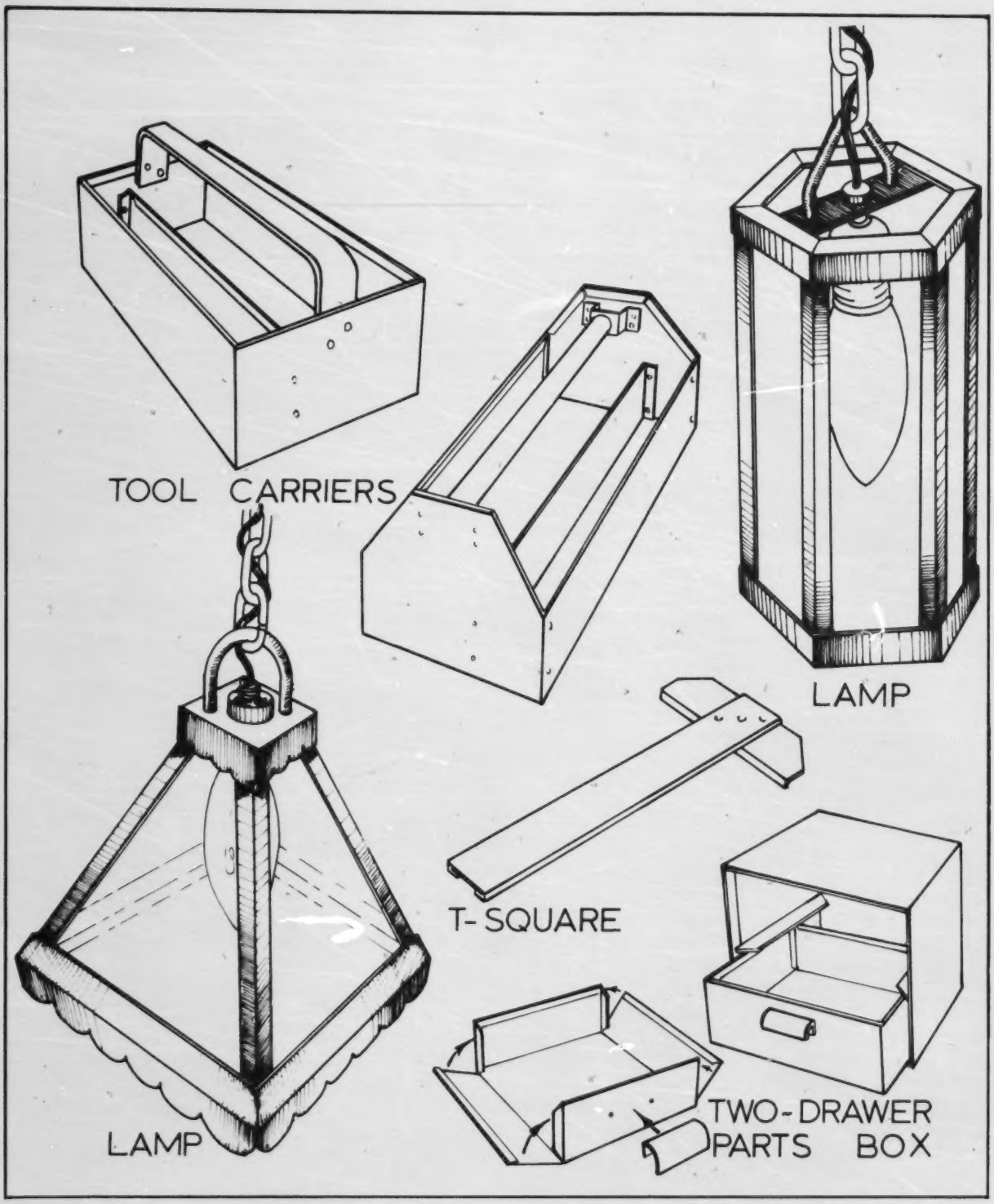
TRAINING: Some sheet metal workers have acquired skills of the trade by working for several years as helpers, observing or being taught informally by experienced workers. However, most authorities recommend the completion of a four-year apprenticeship program as the best approach for learning the sheet metal trade. The apprentice, in addition to learning the use of sheet metal equipment, also receives related classroom instruction in such subjects as drafting, blueprint reading, and mathematics applicable to layout work.

SUGGESTED QUESTIONS: SHEET METAL

Completion Type

1. The most common measuring tool used in sheet metal work is the _____.
2. Sharp, accurate layout lines are made on sheet metal by using a_____.
3. To scribe a circle on sheet metal, the tool to use is the_____.
4. To check the squareness of metal surfaces, the tool usually used is the_____.
5. Measuring angles on sheet metal is accomplished with the aid of_____.
6. The thickness of sheet metal can be measured to the thousandth of an inch with the use of the_____.
7. When cutting light gage metal by hand, the tool to use is the_____.
8. The foot powered machine that is used for cutting large size sheets of metal in the shop is the_____.
9. Lay out the shape of the sheet metal part directly on the metal or trace the shape of the part with the use of a _____.
10. To flatten sheet metal without marring the surface, use the_____.
11. Sharp edges or burrs on sheet metal can be removed with the_____.
12. A fold of less than one inch in width is usually made on the_____.
13. Sheet metal cylinders of various diameters can be formed on the_____.
14. A rectangular box can be folded on the_____.
15. During soldering, to prevent the oxidation of metals while they are being heated, it is essential to use_____.
16. When rivets are used in fastening sheet metal, the head of the rivet is formed with the_____.
17. In industry, prior to riveting, most holes are made in sheet metal with the_____.
18. Tin plate is produced by coating tin on a sheet of_____.
19. Galvanized iron is produced by coating the base metal with_____.
20. Sheet metal is manufactured in a _____.

SHEET METAL: Alternate Product Ideas



SELECTED RELATED MATERIALS

Sheet Metal

Books

Anderson, Algot E. *Problems in Elementary Sheet Metalwork*. Bloomington, Ill.: McKnight and McKnight, 1959.

Bruce, Leroy F. and Meyer, Leo A. *Sheet Metal Shop Practice*. Chicago: American Technical Society, 1968.

Feirer, John L. *General Metals*. New York: McGraw-Hill, 1967.

Giachino, J. W. *Basic Sheet Metal Practice*. Princeton: D. Van Nostrand, 1952.

Ludwig, Oswald A. and McCarthy, Willard J. *Metalwork Technology and Practice*. Bloomington, Illinois: McKnight and McKnight, 1969.

Smith, Robert E. *Sheet Metalwork*. Bloomington, Illinois: McKnight and McKnight, 1961.

Walker, John R. *Modern Metalworking*. Homewood, Illinois: Goodheart-Willcox, 1970.

Wilkinson, H. *Basic Sheet Metal Work*. New York: St. Martins, 1964.

Brochures and Pamphlets

The Can Manufacturing Industry. Can Manufacturers Institute, Inc., 821 15th St. N. W., Washington, D.C. 20005.

A Look at the Art of Punching. Di-Acro Houdaille, Di-Acro Division, Houdaille Industries, Inc., Lake City, Minn. 55041.

A Look at the Art of Forming. Di-Acro Houdaille, Di-Acro Division, Houdaille Industries, Inc., Lake City, Minn. 55041.

Soldering Tips—Your Guide to Easy Soldering. Weller Electric Corp., Easton, Pa. 18042.

Uses of Aluminum. Aluminum Company of America, 1254 Alcoa Building, Pittsburgh, Pa. 15219.

Tin and Its Uses. Tin Research Institute, Inc., 483 West Sixth Ave., Columbus, Ohio 43201.

Films

A Product of the Imagination (28 min). Examines the fascinating past of aluminum, reviews its versatile role in our present civilization, and gives a glimpse of its exciting future.
Motion Picture Section, Aluminum Company of America, 1246 Alcoa Building, Pittsburgh, Pa. 15219.

Bright Steel (30 min). Story of tinplate, how it made possible the modern cannning industry and how familiar household products are packaged and protected in a variety of colorful tinplate containers.
Modern Talking Picture Service, 1212 Avenue of the Americas, New York, N. Y. 10036.

Story of Stainless (27 min). History and development of stainless steel, including the manufacture and uses of stainless steel sheet.
Republic Market Research Division, 1436 Republic Bldg., Cleveland, Ohio 44101.

WROUGHT METAL

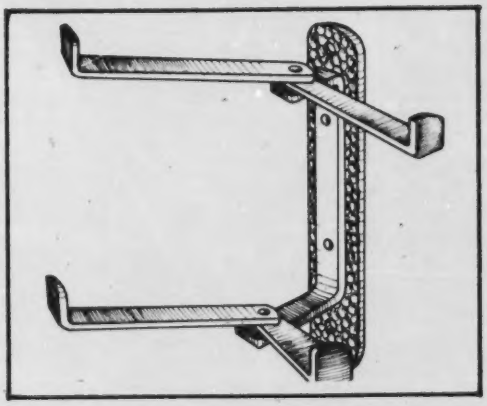
The wrought metals area in the school metalworking shop provides the student with the opportunity to hammer, twist, bend, and otherwise manipulate the metal to conform to a desired shape. It includes ornamental metal which uses wrought iron, and other malleable materials and forging, either hot or cold, which makes possible the production of tool parts.

Ornamental metalwork entails the use of wrought iron, mild steel, aluminum and other metals that are obtainable in the form of strips, bars, rods, sheets, wire, and tubes. These materials can be cold worked, readily twisted, and bent into angles, scrolls, and irregular curves. In the school shop, hand tools and vises facilitate the shaping of these metals, while in industry power presses form the components to specified shapes. The relative ease of assembly by means of welding or riveting has resulted in a multitude of products that fit into the wrought metals category. These products range from wrought iron chairs, tables and other furniture to ceiling fixtures, floor lamps, and other lighting devices.

Forging is concerned with the hammering or pressing of metals, usually while they are hot. Heating makes the metal more malleable or plastic so that it is easier to shape. In addition, forging adds strength and toughness to metal. This fact means that parts can be made smaller and lighter than if other methods of shaping were used. Forged products in the aircraft, missile and spacecraft industries are therefore used where great strength and minimum size and weight are of the utmost importance.

UNIT PRODUCTION: Wrought Metal

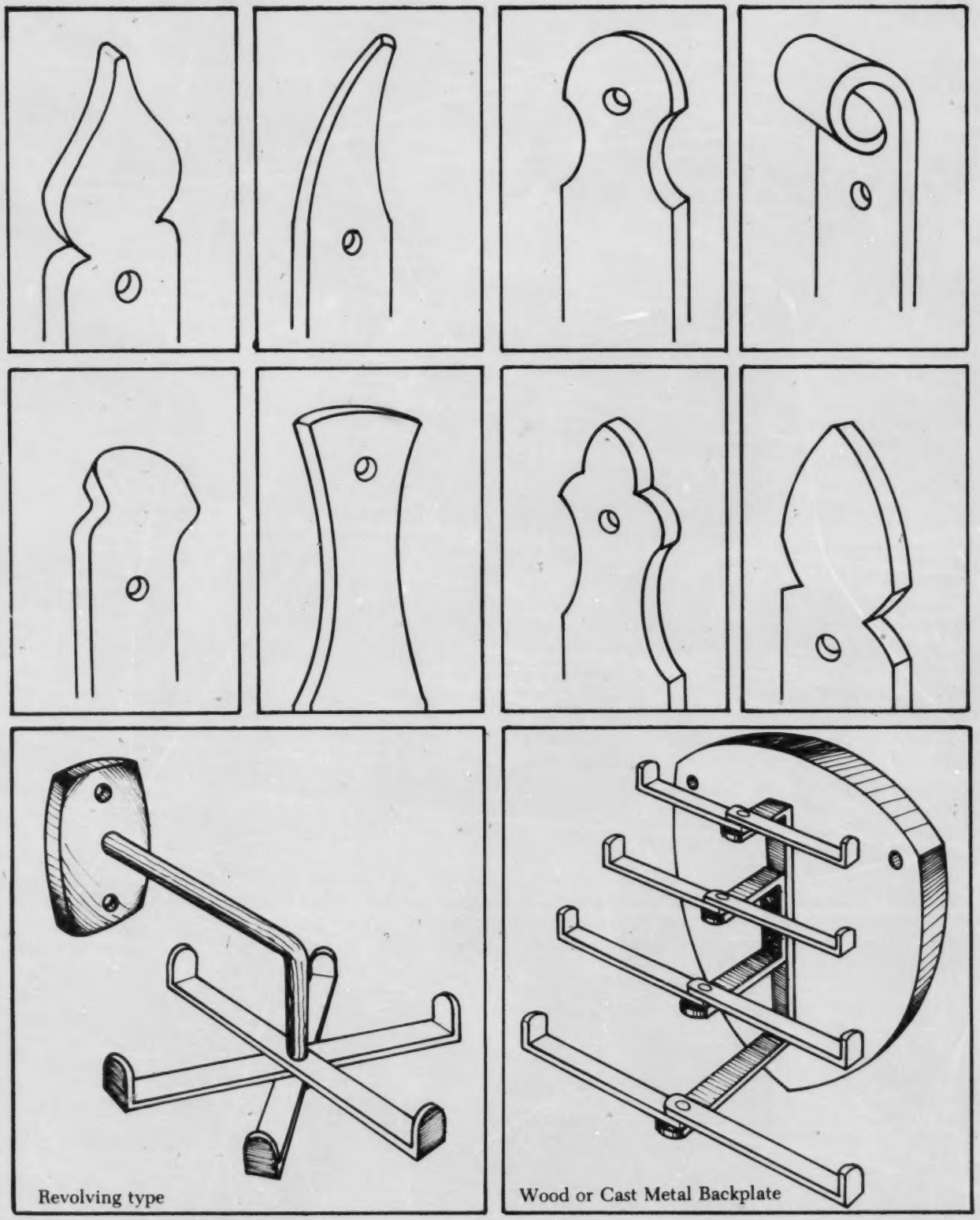
PRODUCT: Tie Rack

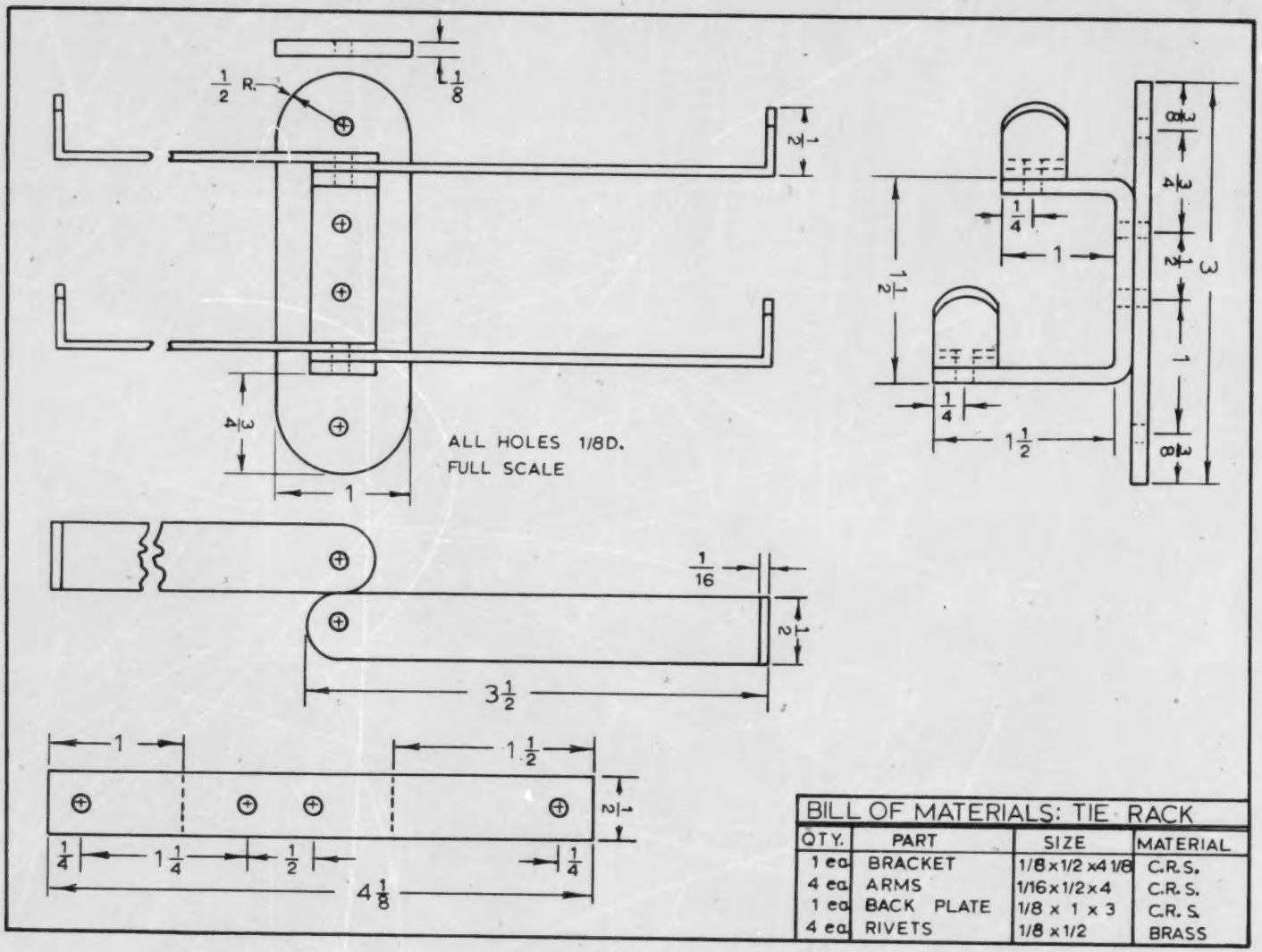


This product serves a useful function in the home. The swinging arm feature of the tie rack not only facilitates the storing of ties, but also adds interest to the item.

A wide range of design possibilities exists. The vertical member to which the bracket arms are attached can be shaped so as to denote a colonial or contemporary style. Spot welding, riveting, or the use of machine screws offer a choice of assembly methods. A number of surface treatments to decorate the vertical component are also available to satisfy individual preference. Further design changes are possible by combining the swinging arm bracket to a backplate constructed from another material such as wood or metal cast in the foundry.

TIE RACK: Alternate Design Ideas





BILL OF MATERIALS: TIE RACK			
QTY.	PART	SIZE	MATERIAL
1 ea.	BRACKET	1/8 x 1/2 x 4 1/8	C.R.S.
4 ea.	ARMS	1/16 x 1/2 x 4	C.R.S.
1 ea.	BACK PLATE	1/8 x 1 x 3	C.R.S.
4 ea.	RIVETS	1/8 x 1/2	BRASS

OPERATION SHEET

TIE RACK

Sequence	Operation Description	Tools and Equipment
1	Cut stock to various lengths (⅛" oversize)	Steel rule, hacksaw, vise
2	Lay out radii, bends, and hole locations	Steel rule, square, center punch, hammer, scriber, dividers
3	Round ends	File, vise
4	Drill holes	Drill press, twist drill, clamp
5	Countersink rear rivet holes in backplate	Countersink, hand drill, vise
6	Fold bends to 90 degree angle	Ball peen hammer, vise, square
7	Clean and polish components	Emery cloth
8	Apply finish	Lacquer – spray or brush
9	Assemble arms to bracket. Check movement.	Rivet set, ball peen hammer, steel block, rivets
10	Assemble bracket to backplate	Rivet set, etc.
11	Final inspection for quality and workability of product.	

DEMONSTRATION LESSON PLAN

Topic: Riveting

Aim: To teach procedure for riveting in the school shop and to acquaint students with methods used in industry.

Preparation:

Ball peen hammer	File	Vise
Rivet set	Steel block	Metal pieces
Rivets	(anvil or stake)	(pre-drilled)

Motivation:

Display components of tie rack (without holes)
Elicit methods of fastening pieces: bracket to vertical support; movable arms to bracket.

Presentation:

1. Clamp steel block in vise. SAFETY: BLOCK SHOULD BE CLAMPED SECURELY.
2. Place rivet through holes of metal components with head of rivet resting on steel block.
3. Draw metal parts together by placing rivet set over body of rivet and hitting lightly the top of rivet set with ball peen hammer.
4. Remove rivet set and begin to head rivet by first striking it with the hammer. Body of rivet will expand to fit tightly in the hole.
5. SAFETY: KEEP FINGERS AWAY FROM FACE OF HAMMER.
6. Form head of rivet with the round depression of rivet set. Rivet head should be round and smooth.
7. Industrial Relationship -- Mention other methods of riveting: Pop riveter, or for large quantities of mass produced items, riveting is done on power-driven automatic riveting machines.

Summary:

Review sequence
Elicit safety precautions

Application:

Students rivet movable arms to bracket. Clearance is required for movement.
Bracket is riveted to vertical component.

Assignment:

Draw a sketch of the three common rivet head shapes in notebook.
List the factors that must be known when ordering rivets.

References:

Feirer, John L. and Lindbeck, John R. I.A. Metalwork. Unit 26, "Riveting," pp. 116-119.
Ludwig, Oswald A. and McCarthy, Willard J. Metalwork Technology and Practice. Unit 36, "Rivets and Riveting," pp. 266-272.

RELATED LESSON PLAN

Topic: Forging Metal

Aim: To teach basic concepts relating to forging and its application in the tool and machine industry.

Preparation:

Wrench Pliers Screwdriver Hammer

Visual Aids:

Photographs Drop Forge Colonial Forged Products

Motivation:

How was metal shaped in colonial times?
What was the role of the blacksmith?

Presentation:

1. Define forging as a forming process by which hot or cold metal is hammered into a desired shape.
2. Indicate some of the required equipment--anvil, tongs, hammer, chisel.
3. Differentiate between hand and machine forging. Display photos of hand forging--colonial door knockers, gates, hinges; samples of machine forging--wrench, etc.
4. Industrial Relationship. Enumerate present day applications of machine forgings performed on drop hammers--automobile gear blanks, connecting rods, railroad car wheels.
5. Explain reason for forging--improves grain structure and relieves the internal stresses thus improving the strength.
6. Mention the opportunities in forging and related activities. Note hazards of the trade.

Summary:

Compare hand and machine forging process.
Review advantages of forging process concerning strength of the product.

Application:

Students will have the opportunity to hammer metal into the desired shape in the construction of the unit production activity--Tie Rack.

Assignment:

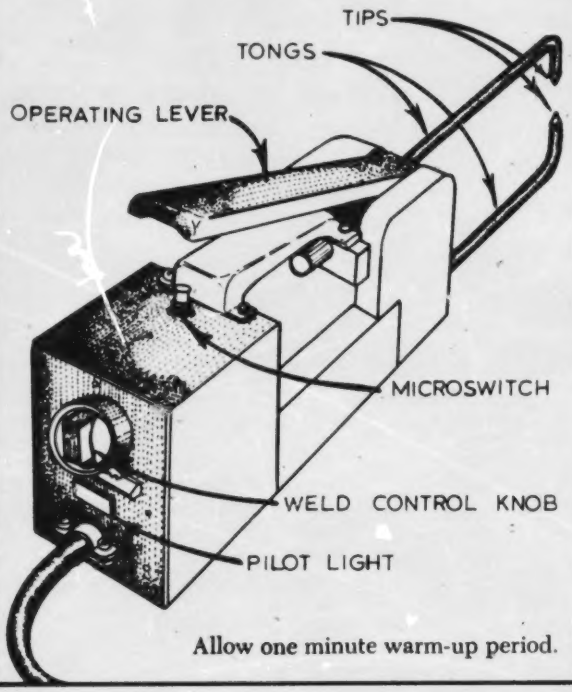
Explain the forging operations. Include sketches
a) Tapering b) Drawing out c) Upsetting
List equipment for hand forging

References:

Feirer, John L. and Lindbeck, John R. I.A. Metalwork. Unit 36, "Forging," pp. 171-175.
Ludwig, Oswald A. and McCarthy, Willard J. Metalwork Technology and Practice. Unit 44, "Tools for Hand Forging," pp. 343-348.

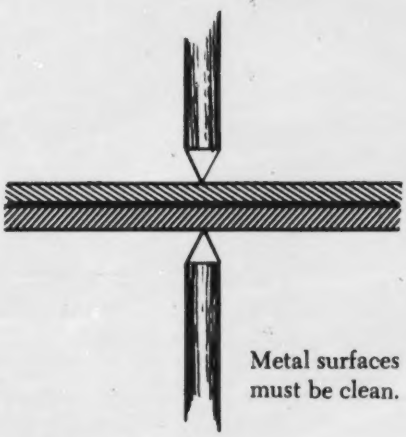
HOW TO SPOT WELD: Instruction Sheet

1. Turn on the electronic timer by turning the weld control knob in a clockwise direction.



Allow one minute warm-up period.

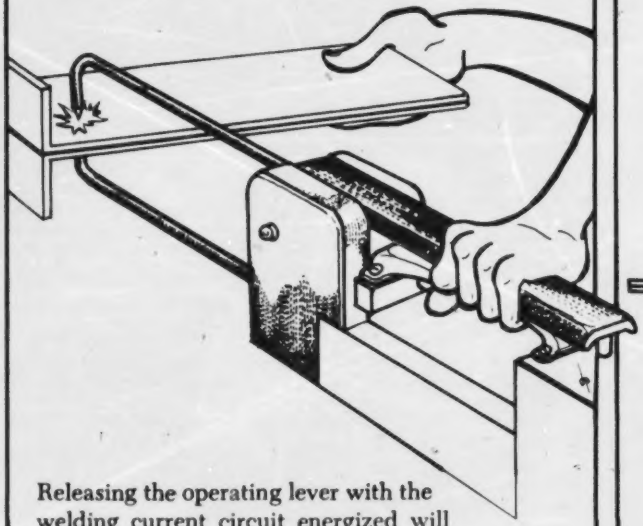
2. Place metals firmly together and position between tong tips.



Metal surfaces must be clean.

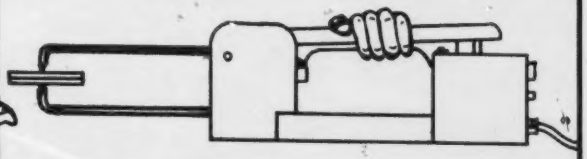
Never apply weld current to tong tips without having metal between them.

3. Depress operating lever to activate microswitch. Do not release the operating lever until the timer has timed out.



Releasing the operating lever with the welding current circuit energized will cause excessive burning of the tong tips.

4. Continue depressing lever until cycle is completed.



Current will flow through the tongs and tong tips until the timing and welding current are automatically stopped.

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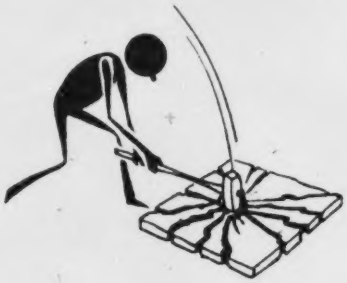
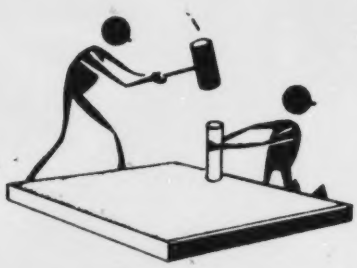
PHYSICAL PROPERTIES OF METALS: Related Information Sheet

BRITTLENESS is that property of a metal that allows it to break or crack readily if dropped or hit with a hammer. (Brittle metals break easily.)

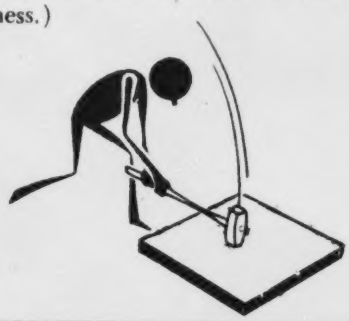


DUCTILITY permits a metal to be drawn out or stretched without breaking. (Ductile metals are easily deformed.)

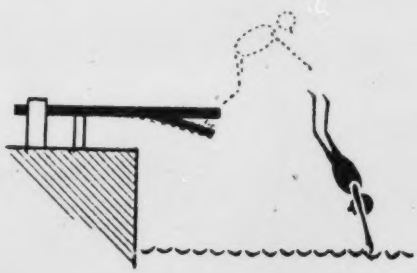
HARDNESS is the resistance of a metal to be dented or penetrated. Hard metals resist penetration.



TOUGHNESS is that property of a metal to withstand shock or impact. (Toughness is the opposite condition to brittleness.)



ELASTICITY is the property of a metal to return to its original shape after bending. (Elastic metals return to their original shape after the load is removed.)

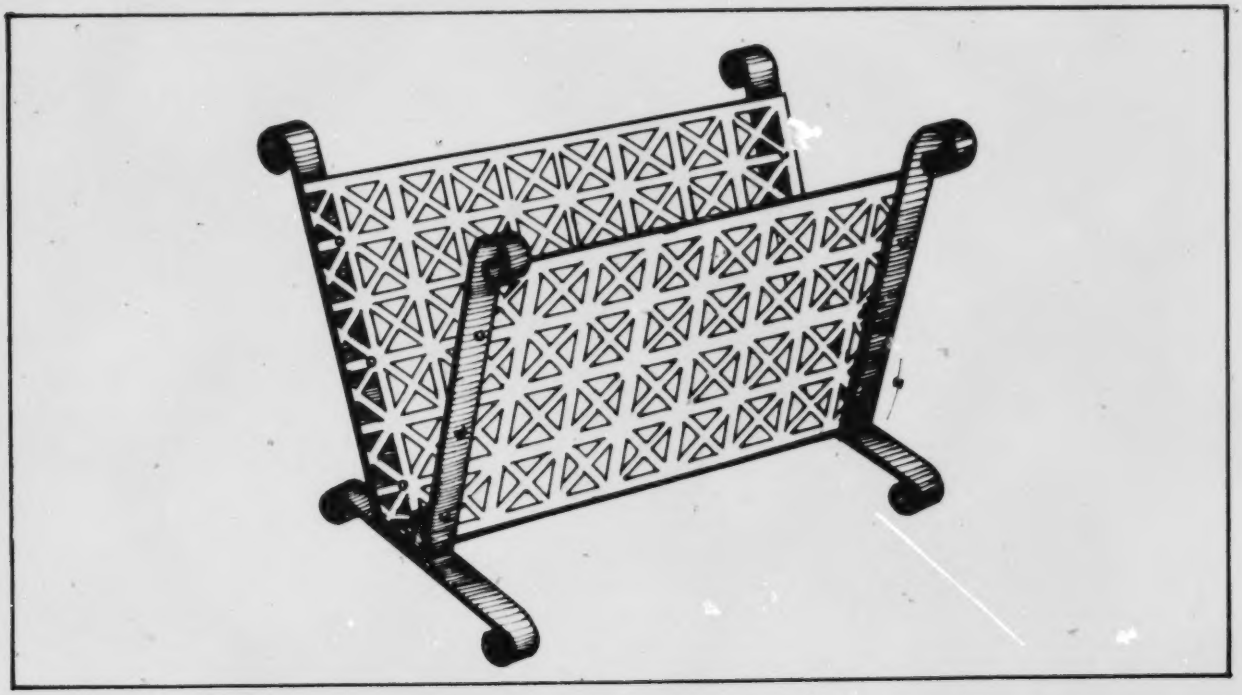


MALLEABILITY is that property of a metal that allows it to be hammered, rolled, or bent without cracking or breaking. Malleable metals may be easily formed.

TENSILE STRENGTH is the maximum amount of pull that a metal will withstand before breaking. Tensile strength is the amount that a metal will resist a direct pull.

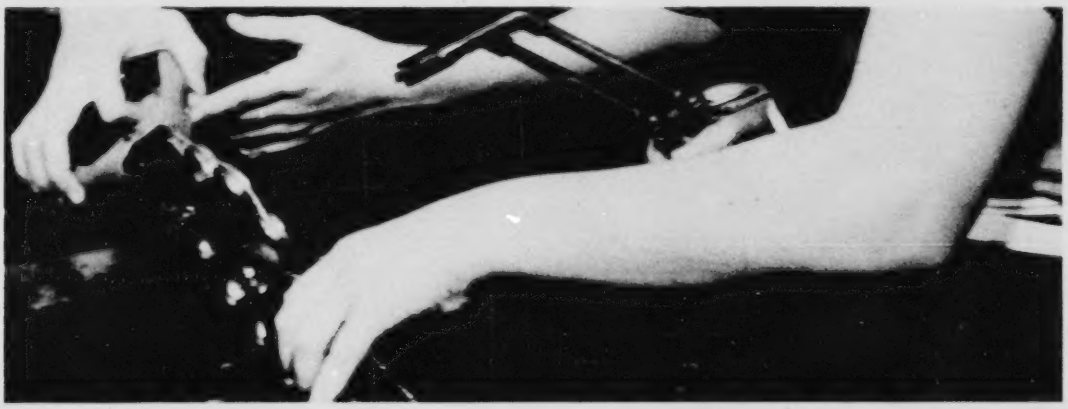
MASS PRODUCTION: Wrought Metal

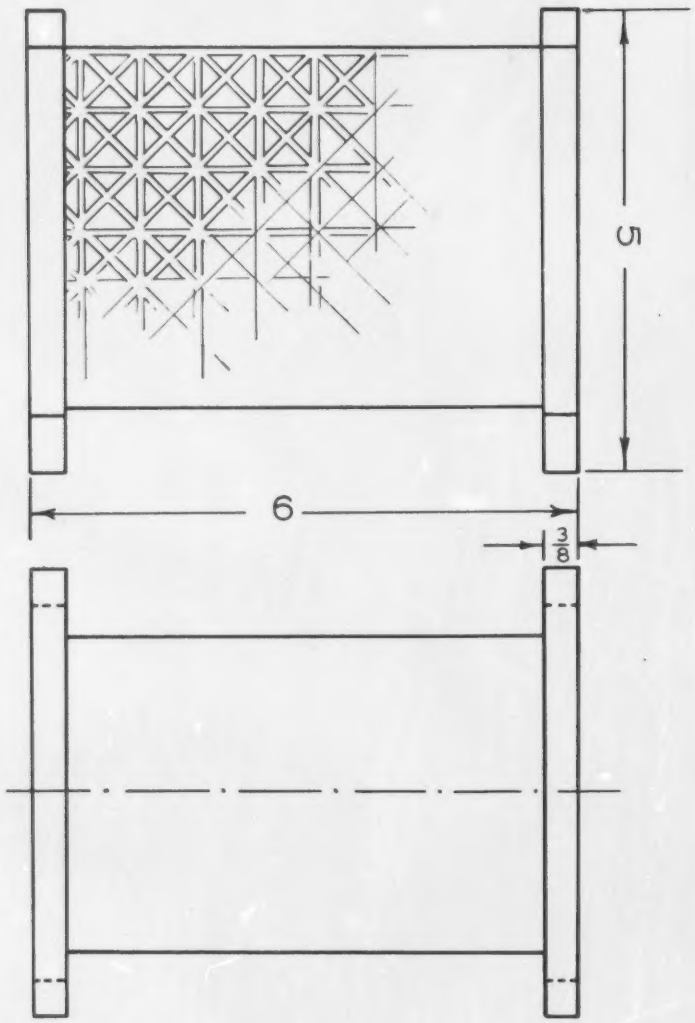
PRODUCT: Letter Holder

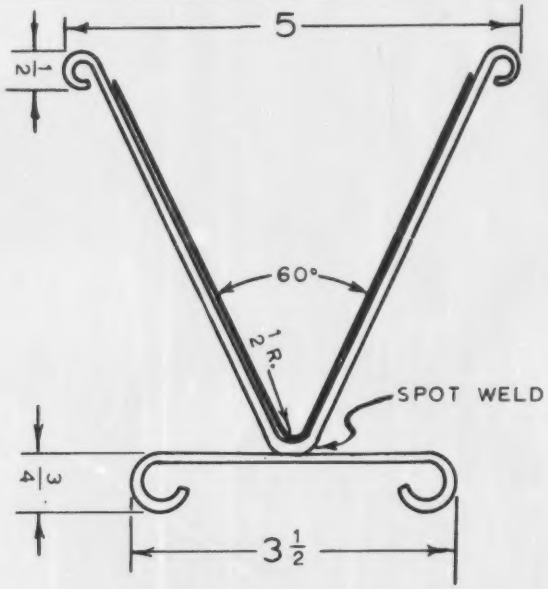


This wrought metal product is a salable item because of its usefulness and attractiveness. It is a device for conveniently holding letters in a neat manner where they can be readily obtained. Another application would be its use as a napkin holder.

The basic design can be modified by omitting the scroll bends and substituting supports that are tapered and reflect a contemporary style. Perforated sheet steel can be ordered in a variety of patterns. Mass production of the item can be expedited by using a bending fixture, spray finishing, and spot welding the components for final assembly.







LETTER OR NAPKIN HOLDER

BILL OF MATERIALS

QTY.	PART	SIZE	MATERIALS
2	BASE SUPPORT	$\frac{1}{16} \times \frac{3}{8} \times 7$	C R S
2	SIDE ARM	$\frac{1}{16} \times \frac{3}{8} \times 12$	C R S
1	SIDE PIECE	6 x 8 x 26 GA.	PERF. STEEL

64

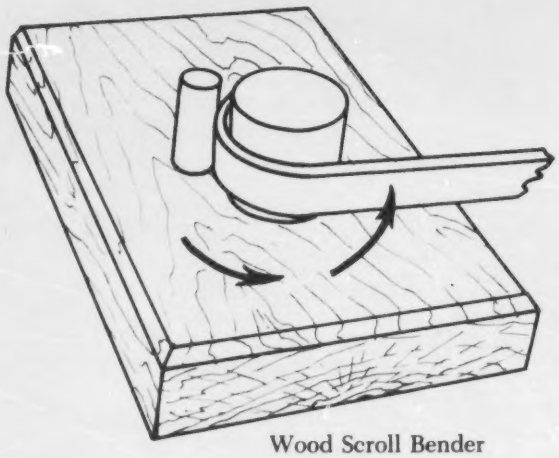
89

OPERATION SHEET

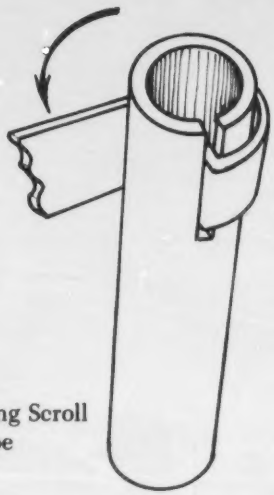
LETTER HOLDER

Sequence	Operation Description	Tools and Equipment
1	Cut base supports and side arms to length. (Mount multiple pieces of stock in vise)	Scratch awl, rule, steel hacksaw, vise
2	Remove sharp corners and burrs	File, emery cloth
3	Form scroll on each end	Bending fixture, vise
4	Form 60 degree Vee bend in side arms	Bending fixture, vise
5	Weld base support to side arm	Spot weld
6	Cut perforated steel side to size. Set stop gage. File top edge for safety.	Foot shears, steel rule, file
7	Form 60 degree Vee bend in perforated steel sheet	Bending fixture, vise
8	Attach perforated steel side to wrought metal assembly	Spot weld
9	Apply finish	Spray
10	Final inspection	

LETTER HOLDER: Bending Fixtures

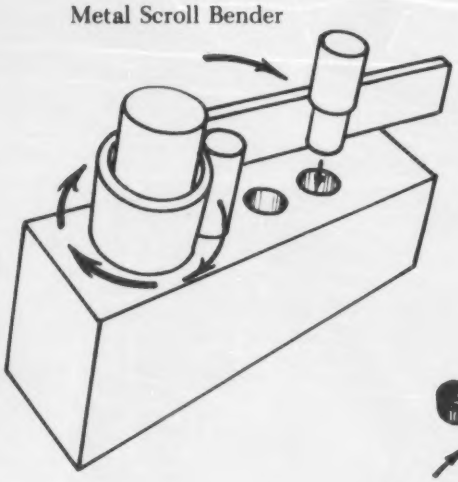


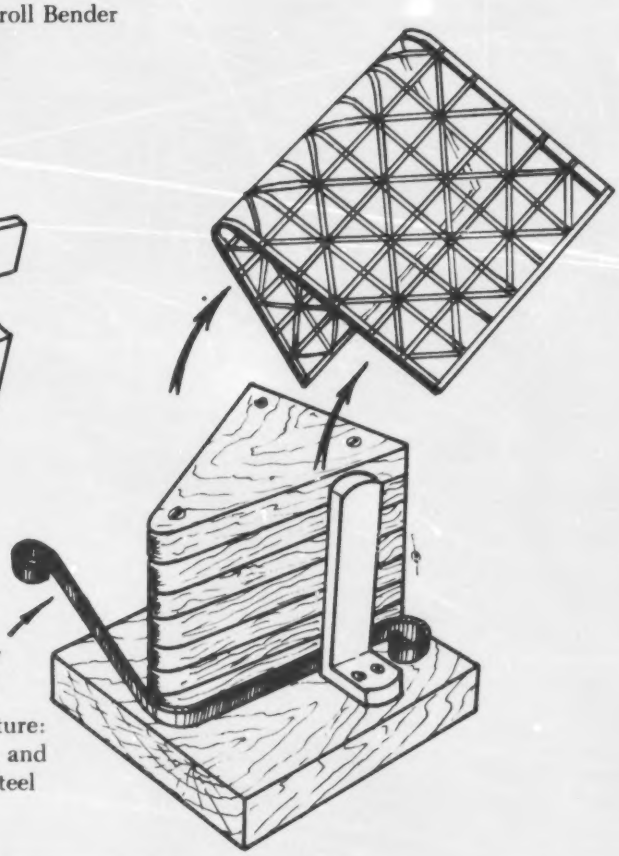
Wood Scroll Bender



Bending Scroll
on Pipe

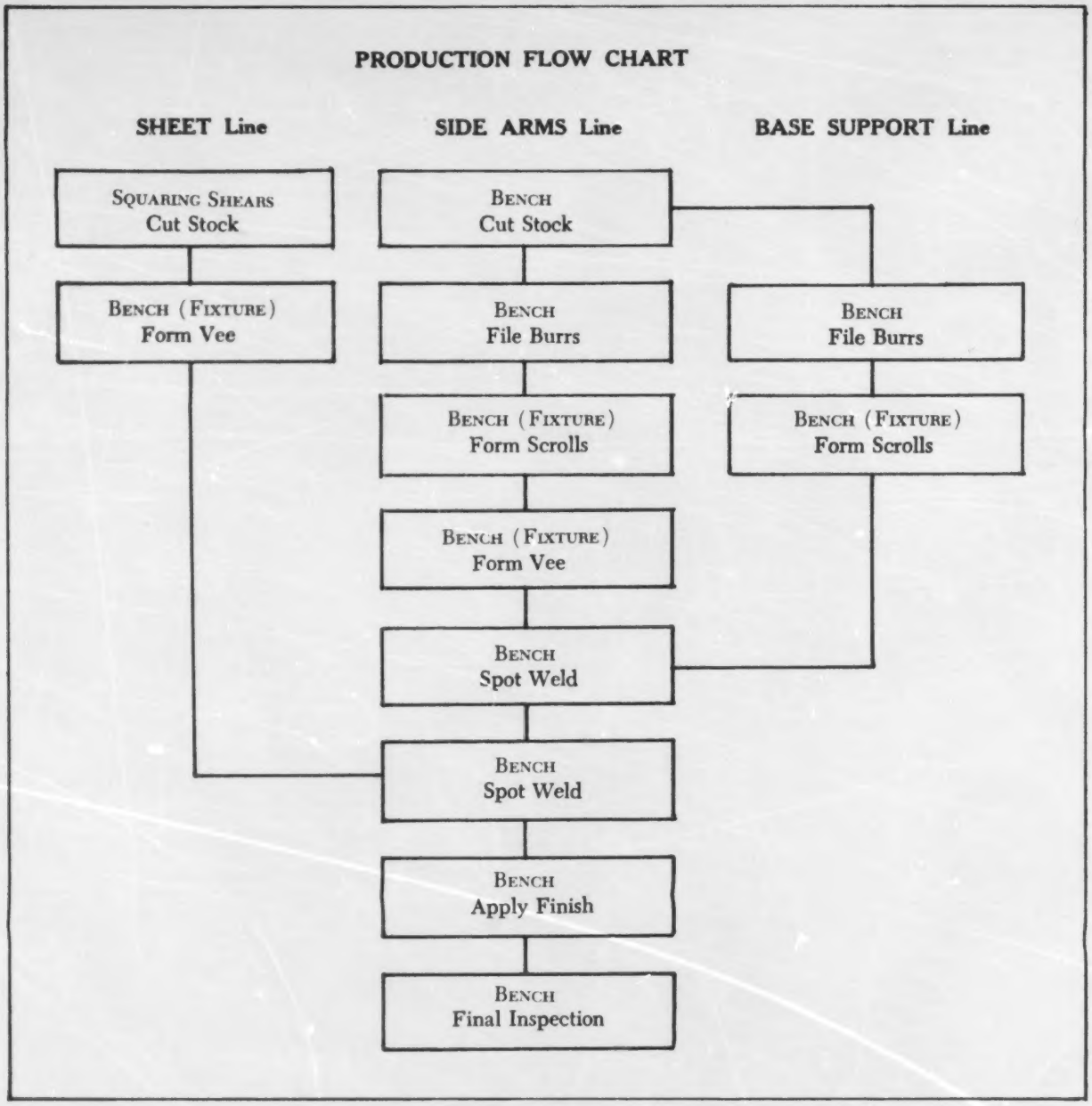
Metal Scroll Bender





Bending Fixture:
Side Bracket and
Perforated Steel

LETTER HOLDER



OCCUPATIONAL INFORMATION: Wrought Metal Area

ORNAMENTAL IRON WORKER

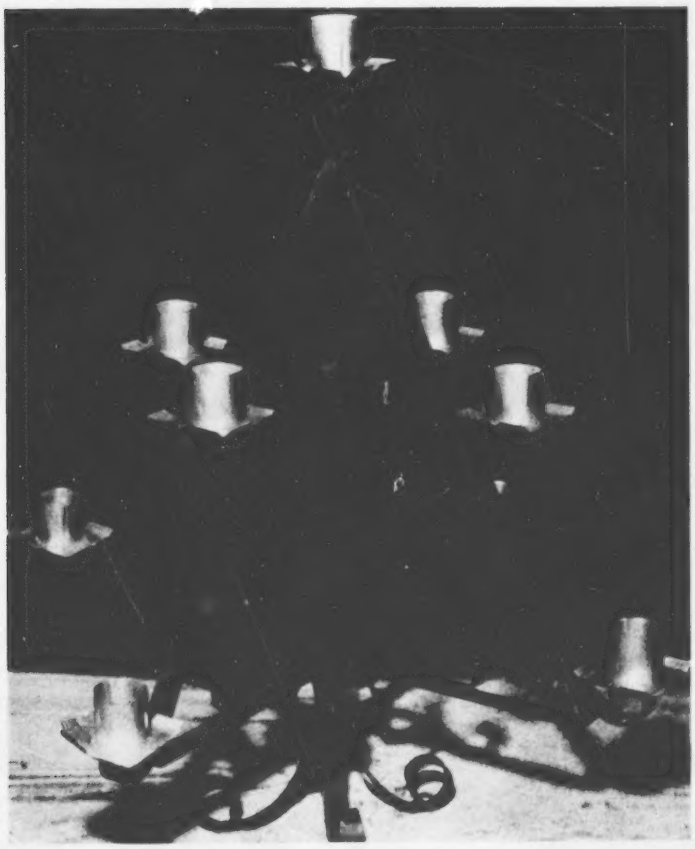
TYPE OF EMPLOYMENT: The ornamental iron worker installs metal stairways, floor gratings, iron ladders, metal window sash and doors, grilles and screens. This worker also installs lampposts, gates, fences and decorative ironwork on balconies. In addition to iron and steel, the ornamental iron worker works with aluminum, brass, and bronze metal shapes, frames and panels. The products which are installed have usually been fabricated in a factory or shop.

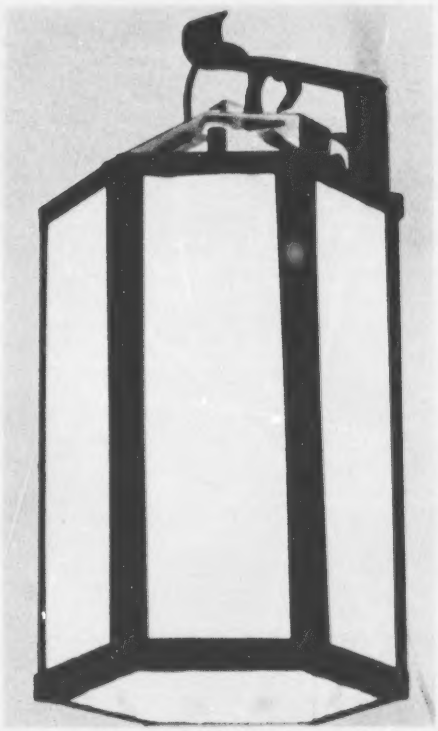
WHERE EMPLOYED: The ornamental iron worker can be employed by general contractors on large building projects, ornamental iron contractors, or can be self-employed.

TRAINING: Most training authorities recommend the completion of a three-year apprenticeship as the best way to learn this trade. The apprenticeship program usually consists of three years of on-the-job training, given by either the supervisor or an experienced ornamental iron worker.

In a typical training program, the apprentice learns to care for and handle tools, machines, and equipment used in the trade; read blueprints and working drawings; form, shape, drill, tap, erect and assemble various metal structures; lay out and assemble steel stairs, fire escapes, grilles, railings, doors, and related metal structures. The apprentice also learns how to weld, bolt, and rivet, and how to repair metal structures. Included in the program is related classroom instruction in subjects such as drafting, blueprint reading, and mathematics applicable to layout work.

Interesting design and construction of wrought iron candelabra





Wrought metal bracket provides support for hanging wall lamp

SUGGESTED QUESTIONS: Wrought Metal

Place the letter of the correct answer in the space provided in the left hand column.

_____ 1. Bar stock can be cut to length with the:
a) file
b) jeweler's saw
c) hack saw
d) cutting pliers

_____ 2. To prevent the point of a twist drill from moving away from the exact location:
a) center punch the metal
b) press hard on the drill
c) soften the metal
d) clamp the metal

_____ 3. The part of the twist drill that is held in the chuck of the drill press is the:
a) flute
b) shank
c) web
d) edge

_____ 4. When handling hot metals in the gas furnace use:
a) pliers
b) clamps
c) wrench
d) tongs

_____ 5. Forging or heavy hammering is done on the:
a) top of the vise
b) top of the bench
c) floor
d) anvil

_____ 6. Steel is softened by:
a) bending back and forth
b) hammering
c) heating and cooling slowly
d) soaking

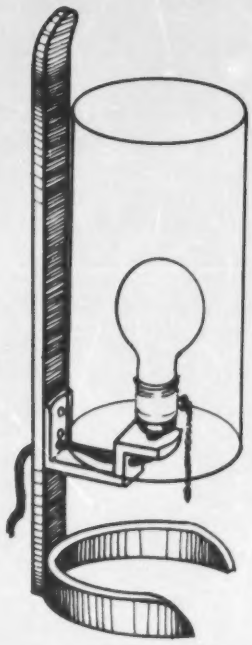
_____ 7. Band iron is:
a) mild steel
b) medium carbon steel
c) tool steel
d) alloy steel

_____ 8. In the automobile industry, riveting has been largely replaced by:
a) soldering
b) welding
c) nuts and bolts
d) epoxies

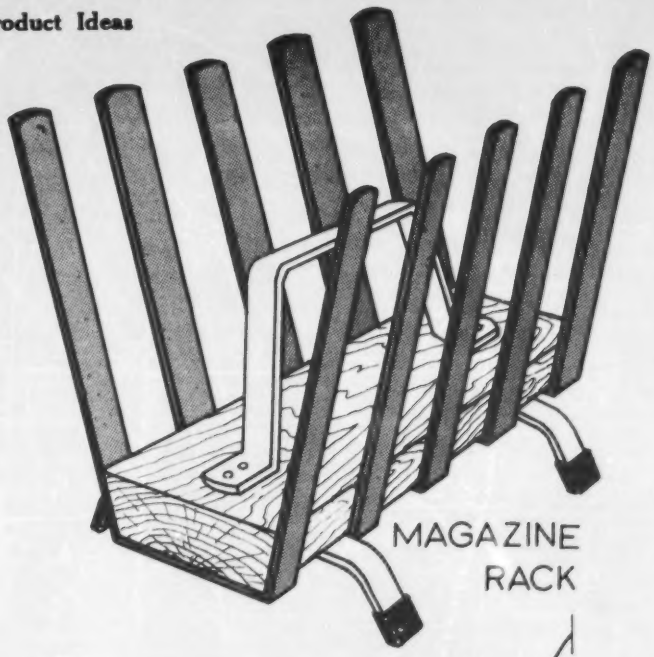
_____ 9. Before using a cold chisel with a mushroom head:
a) ask permission
b) use reasonable care
c) hit the head lightly
d) ask the teacher to grind the head back to normal

_____ 10. Tool steel is hardened by heating it to the correct temperature and:
a) cooling it in the furnace
b) quenching it in oil or water
c) cooling it by placing it in sand
d) cooling it slowly in air

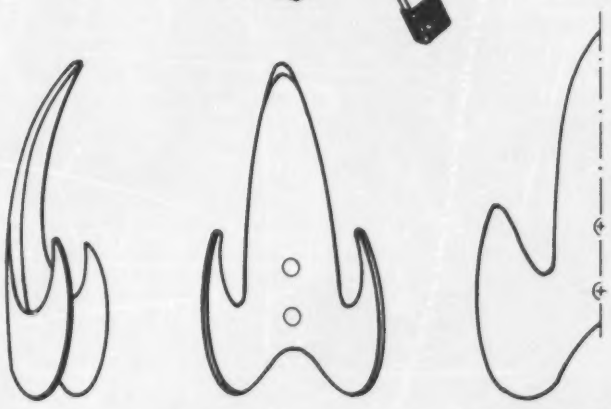
WROUGHT METAL: Alternate Product Ideas



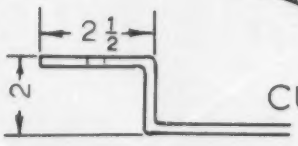
LAMP



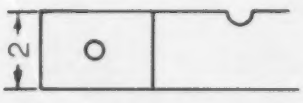
MAGAZINE RACK

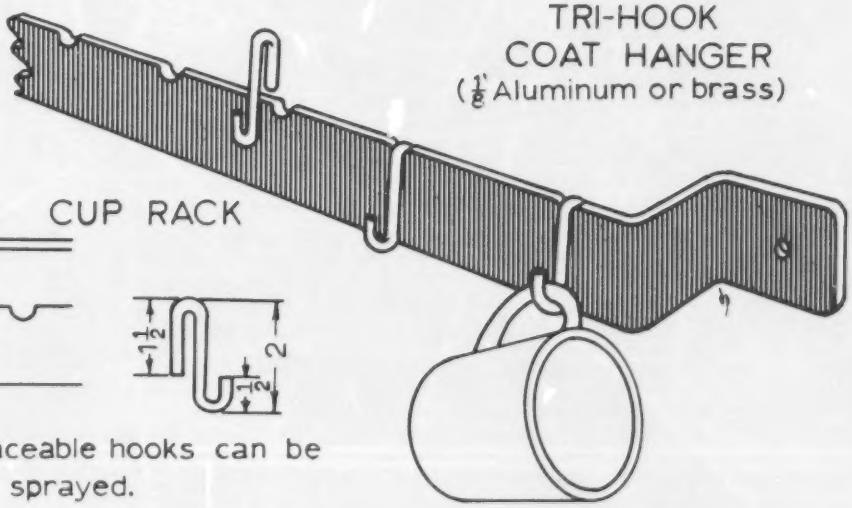


TRI-HOOK COAT HANGER
($\frac{1}{8}$" Aluminum or brass)



CUP RACK





Movable replaceable hooks can be dip coated or sprayed.

SELECTED RELATED MATERIALS

Wrought Metal

Books

Barich, Dewey F. and Smith, Leonard C. *Metal Work for Industrial Arts Shops.* Chicago, Illinois: American Technical Society, 1967.

Bedford, John R. *A Basic Course of Practical Metalwork.* London: Martin's, New York: Transatlantic Arts, 1960.

Boyd, Gardner D. *Metalworking.* Homewood, Illinois: Goodheart-Willcox, 1964. Unit 4, "Bench and Wrought Metal," pp., 14-16.

Dragoo, Alva W. *General Shop Metalwork.* Bloomington, Illinois: McKnight & McKnight, 1964.

Kuhn, Fritz. *Wrought Iron.* New York: Architectural, 1969.

Lister, Raymond. *The Craftsman in Metal.* New York: A. S. Barnes, 1968.

Ruley, M. J. *Practical Metal Projects.* Bloomington, Illinois: McKnight & McKnight, 1970.

Ruley, M. J. *Projects in General Metalwork.* Bloomington, Illinois: McKnight & McKnight, 1968.

Walker, John R. *Metal Projects.* Homewood, Illinois: Goodheart-Wilcox, 1966.

Underwood, Austin. *Creative Wrought Ironwork.* New York: Van Nostrand, 1965.

Motion Pictures

It's Easy to Bend. Di-Acro Division, Houdaille Industries, 800 Jefferson, Lake City, Minnesota 55041.

Wrought Iron . . . Yesterday . . . Today . . . Tomorrow. Modern Motion Pictures, 3 East 54th St., New York, N.Y. 10022.

To Be Forged. Modern Motion Pictures.

Ornamental Iron Workers. Communications Division, State Education Department, Albany, N.Y. 12224.

The Drama of Metal Forming. Shell Film Library, 450 North Meridian St., Indianapolis, Ind. 46204.

Guides and Pamphlets

A Look at the Art of Forming. Di-Acro Division, Houdaille Industries, 800 Jefferson, Lake City, Minn. 55041.

It's Easy to Bend. Di-Acro Division, Houdaille Industries.

Welding and the World of Metals. Miller Electric Manufacturing Co., Appleton, Wis. 54911.

Handbook for Spot Welding. Miller Electric Manufacturing Company.

Create Useful Metal Products at Home. Creative Educational Services, P.O. Box 154, Parsippany, N. J. 07054.

Why Teach Hot Metals? Johnson Gas Appliance Co., 585 East Avenue N.W., Cedar Rapids, Iowa 52405.

Manufacturing an Open End Wrench. Snap-On Tools Co., 8079 K 28th Ave., Kenosha, Wis. 53140.

Manufacturing a Chisel. Snap-On Tools Co.

The Making of Steel. American Iron and Steel Institute, 150 East 42nd St., New York, N.Y. 10017.

JEWELRY and ART METAL

Jewelry making and art metal work are combined in this unit because these allied activities share common tools, materials, operations and decorative techniques. The tools required are common to the benchwork area, except for those special devices that would be necessary in clamping, sawing, filing and executing specialized and intricate operations. Both areas use copper, brass, sterling silver and other metals. The decorative processes relating to stamping, piercing, enameling, etching and engraving can be applied to both jewelry and art metal products.

Jewelry making and art metal work are highly motivational activities. Products emanating from the jewelry field aim to enhance the personal appearance of the individual, while articles produced in the art metal area serve to embellish the surroundings in which the individual lives. Therefore, when a student is assigned to work in the jewelry-art metal area, he or she can look forward to developing a product which will improve the appearance of the wearer of the jewelry item or enhance the appearance of the home containing the art metal object.

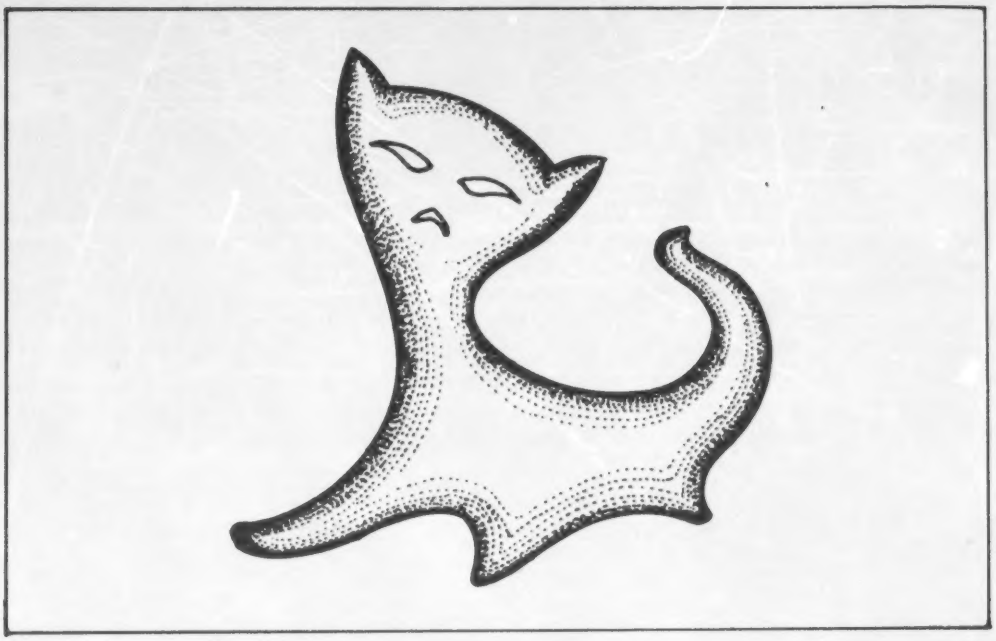
The metalworking teacher should strive to develop the creative talents of each student. Rather than have the class make an exact duplicate from a drawing or imitate the work of another student, the pupils should be urged to select their own forms and create their own designs when they are ready to begin making the prototype for the unit production activity.

To help students to become aware of good design and to recognize and appreciate good workmanship, the student should be encouraged to visit a museum containing jewelry and art metal objects. The Metropolitan Museum of Art, in particular, has exceptional examples of well designed and expertly executed jewelry and art metal articles that have been produced through the ages. By means of outside assignments or field trips, students can examine these items and appreciate the high degree of beauty and craftsmanship that are apparent.

Dancing figures designed and produced in the Jewelry and Art metal area

UNIT PRODUCTION: JEWELRY AND ART METAL

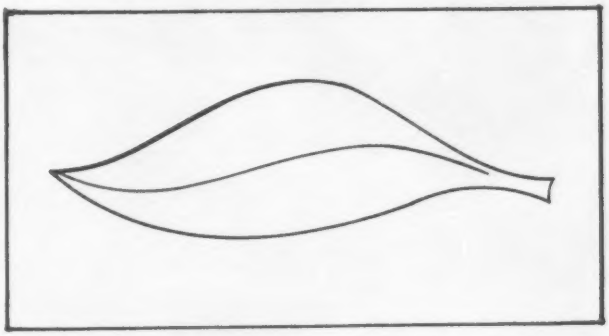
PRODUCT: Decorative Pin



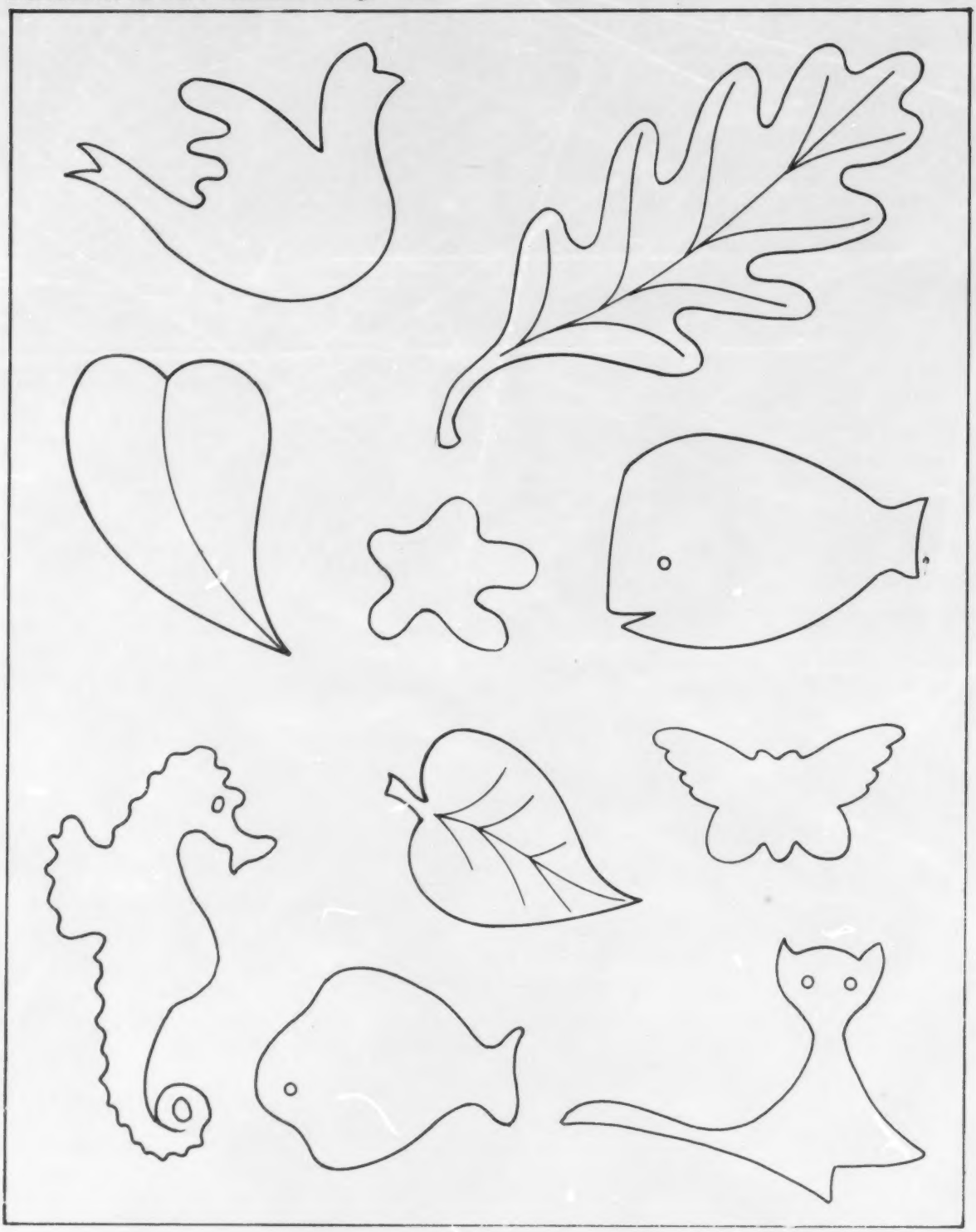
This suggested unit production activity provides the student with the opportunity to develop the basic skills in jewelry and art metal while fabricating an attractive article that possesses strong personal appeal. The pupil will also experience the working properties of a nonferrous metal and will be in a position to compare the characteristics of copper or brass with the ferrous metals that were worked with in previous shop activities.

While the introductory activity that is suggested is the decorative pin, this item can be readily substituted by other similarly fabricated articles such as medallions or pendants, depending on student preference. It should be pointed out that these custom-made pieces are hand wrought, one-of-a-kind items that are unique and therefore would be more highly prized and more expensive than comparable mass produced costume jewelry.

The motifs used should be relatively simple in design and can be based on modified natural forms, geometric shapes, initials and insignias. Students should be encouraged to design their own pins within the limitations specified by the teacher. Enameling and other techniques for decorating the surface of the metal offer further possibilities for increasing the attractiveness of the pin.



DECORATIVE PIN: Alternate Design Ideas



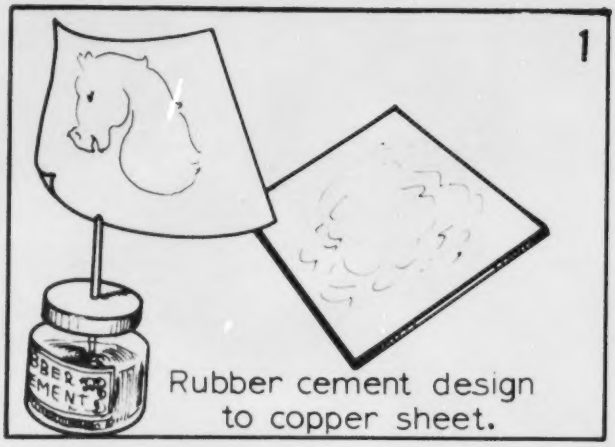
OPERATION SHEET

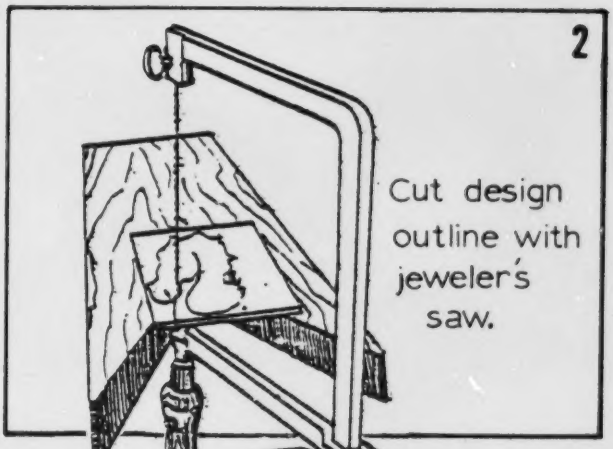
DECORATIVE PIN

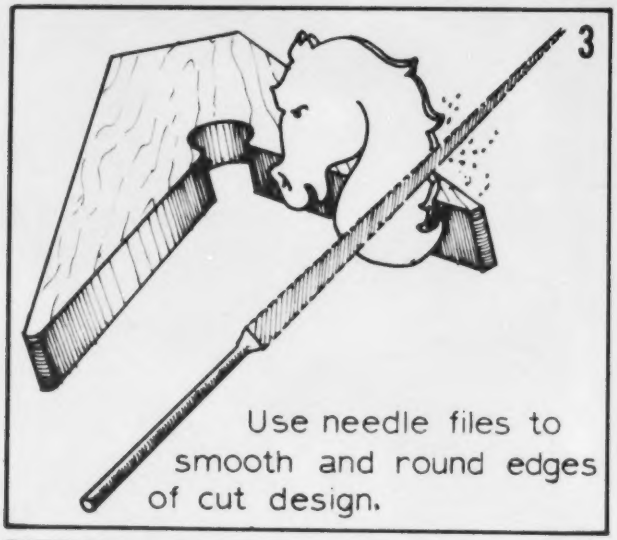
Sequence	Operation Description	Tools and Equipment
1	Sketch design on paper	Tracing paper
2	Transfer design to metal	Rubber cement
3	Cut metal on waste side of line	Vee block, beeswax, jeweler's saw
4	File to line and smooth edges	Needle file
5	Clean the metal	Emery cloth, crocus cloth
6	Solder the finding	Soldering torch, solder, flux
7	Polish the pin	Buffing wheel, Tripoli, rouge
8	Apply protective finish	Lacquer spray

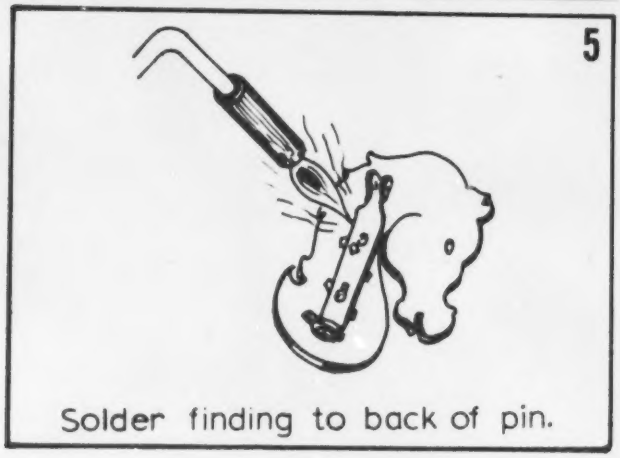
An imaginatively designed metal chess set. The unique pieces rest on a chessboard constructed in combination with metal and wood.

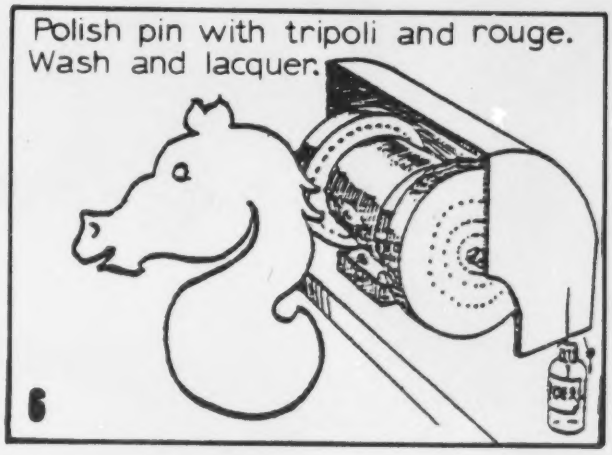
MAKING A DECORATIVE PIN: Sample Instruction Sheet











DEMONSTRATION LESSON PLAN

Topic: Sawing thin guage metal

Aim: To teach the use of the jeweler's saw

Preparation:

V block	Saw blades	Jeweler's saw frame
Beeswax	Bench vise	Sheet copper (design mounted)

Visual Aids:

Chart of jeweler's saw with nomenclature.
Samples of student constructed jewelry pieces.
Instruction sheets for class distribution.

Motivation:

Display attractive samples of student constructed jewelry items.
Stress individuality of design and suitability as gifts.
Elicit responses concerning methods that might be employed in cutting the thin gage metal to the desired shapes.

Presentation:

1. Name and describe the parts of the jeweler's saw.
2. Fasten the blade in the frame. Indicate the direction of the teeth.
3. Hold metal firmly on V block and start sawing operation. Apply beeswax periodically.
4. STRESS SAFETY. KEEP FINGERS AWAY FROM CUTTING EDGE OF BLADE.
5. Explain piercing or cutting internal designs.
6. Industrial Relationship -- Jeweler's saw is used by the metal craftsman to create custom made jewelry. Mass produced jewelry products are punched out on power presses equipped with dies.

Summary: State the advantages of the jeweler's saw over other cutting methods.
In what direction of the stroke does the cutting action take place?
How are intricate shapes mass produced in the jewelry-making field?

Application:

Pupils cut our design for the unit production activity (decorative pin) using the jeweler's saw.

Assignment:

List four causes of blade breakage in the use of jeweler's saw.
Draw a sketch in the shop notebook illustrating the jeweler's saw; name the parts and indicate the direction that the teeth are pointing.

References:

Ludwig, Oswald A. and McCarthy, Willard J. Metalwork Technology and Practice. Unit 11, "Hand Sawing," pp. 84-89.

RELATED LESSON PLAN

Topic: Decorating Metals

Aim: To identify a variety of decorating approaches that are used to increase the attractiveness of jewelry and art metal products.

Preparation:

Samples of jewelry and art metal items.
Photographs of artistic and commercial jewelry and art metal products.
Specimens of metals that illustrate various methods of decoration.

Motivation:

What jewelry do you or members of your family wear?
Why do you enjoy wearing the jewelry?
Why is the jewelry attractive to you?

Presentation:

1. Man throughout history has made jewelry and art metal articles: Purposes -- religious, functional (armor), personal appearance, rank (royalty)
2. Metals made more attractive by: (display samples, specimens, photographs)
   a. Removing metal from metal -- etching, engraving, piercing
   b. Adding metal to metal -- overlaying, riveting, soldering
   c. Tooling metal -- chasing, peening, stamping, fluting
   d. Adding other materials to metal -- jewels, enameling
3. Craftsmen worked in guilds: great silversmiths -- Cellini
4. Today, individual craftsmen are self-employed in small shops producing custom-made jewelry and art metal products, or
   Industry is mass producing articles and using decorating techniques by the application of machine methods and assembly-line approaches.

Summary:

Metal decoration has a long history. Evidence can be observed in many museums.
Much of the craftsmanship of the past has never been surpassed.
Today, despite industrial methods for producing and decorating jewelry and art metal products, the individual jeweler and silversmith who is capable, can own his own business.

Application:

Pupils to choose a decorating method for unit production activity.

Assignment:

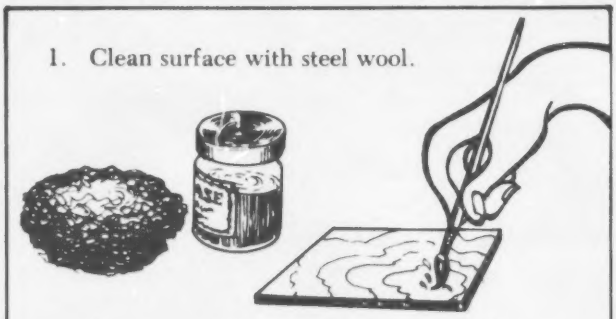
Design four different candy dishes, 3 inches in diameter, 1 inch deep. Indicate by illustration, four different decorating possibilities.

Reference:

Feirer, John L. General Metals. Section Four, "Art Metal and Jewelry", pp. 173-216.

ENAMELING BASE COAT: Sample Instruction Sheet

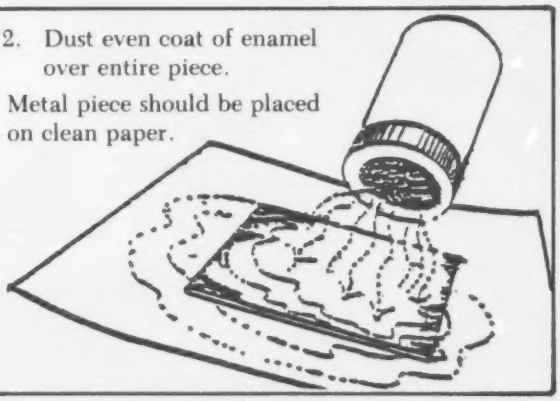
1. Clean surface with steel wool.



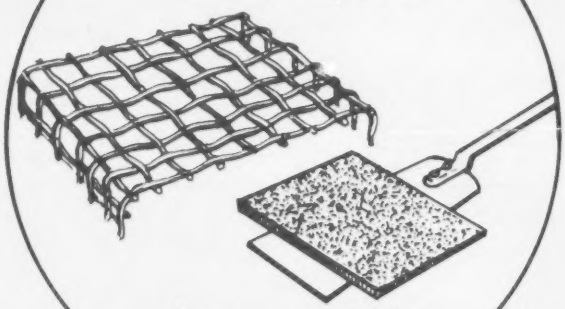
Brush combination metal cleaner and gum solution over entire surface.

2. Dust even coat of enamel over entire piece.

Metal piece should be placed on clean paper.



3. Lift metal piece onto tray using spatula.

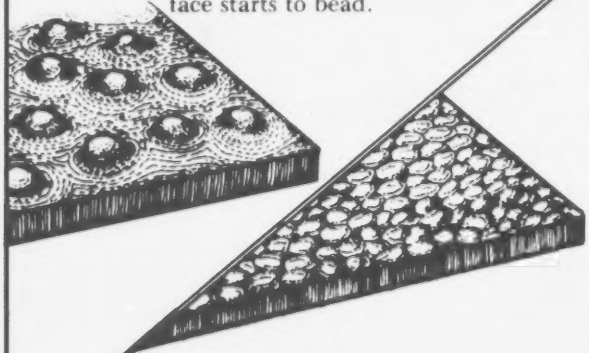


Pour excess enamel from paper back into shaker jar.

4. Place in kiln (1350-1500 F). Within 30 seconds open door slightly to check enamel. Close door until surface is completely smooth and shiny.

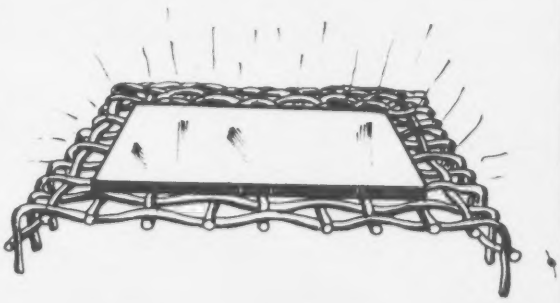
SAFETY: USE PROTECTIVE GLOVES, SHIELDED FORK. WEAR GOGGLES.

5. NOTE: Within 15 or 20 seconds the surface starts to bead.



Within 30 seconds the enamel assumes on orange peel surface.

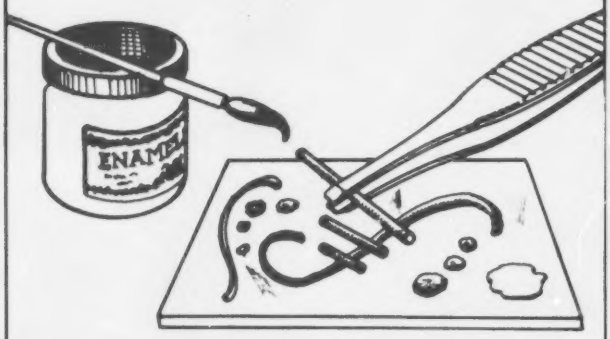
6. Remove piece from kiln when surface is smooth and shiny.



SAFETY: REMAIN WITH ENAMELED PIECE UNTIL IT HAS COOLED.

SURFACE DECORATING IN ENAMELING: Sample Instruction Sheet

1. Apply solid pieces of glass for decoration.

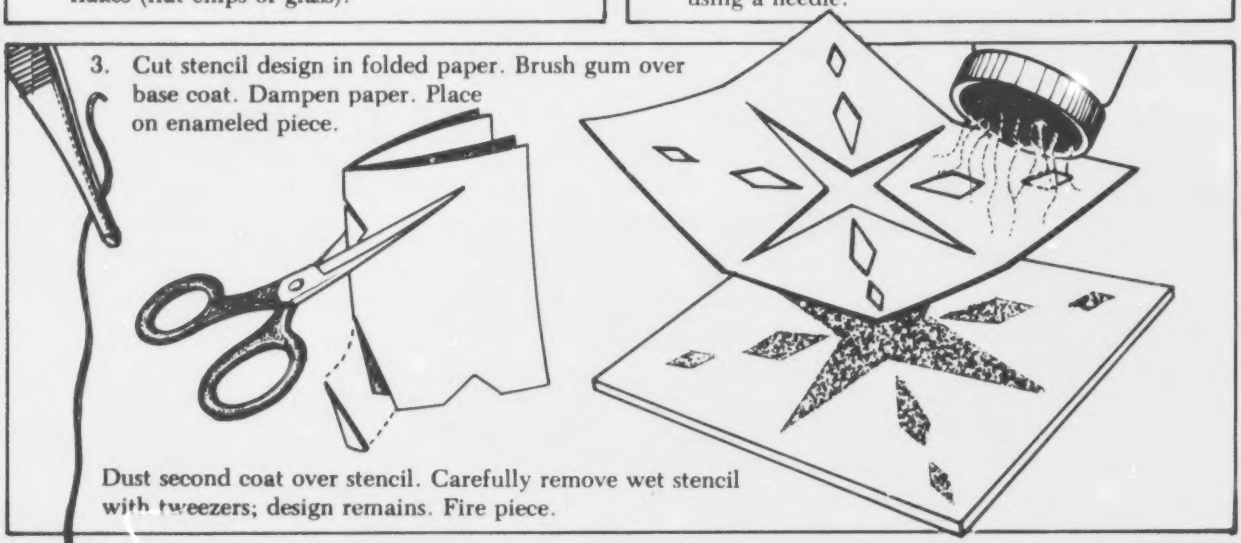


Glass lumps, glass threads, glass rods, glass flakes (flat chips of glass).

2. Use technique known as *sgraffito*.

Sprinkle a contrasting color enamel over the base coat. Scratch through into base coat using a needle.

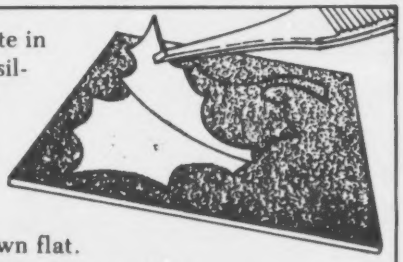
3. Cut stencil design in folded paper. Brush gum over base coat. Dampen paper. Place on enameled piece.



Dust second coat over stencil. Carefully remove wet stencil with tweezers; design remains. Fire piece.

4. Hold wet thread allowing it to loop over itself in a free-form design. Dust a contrasting color enamel over the entire surface. Lift thread straight up leaving a base coat showing through.

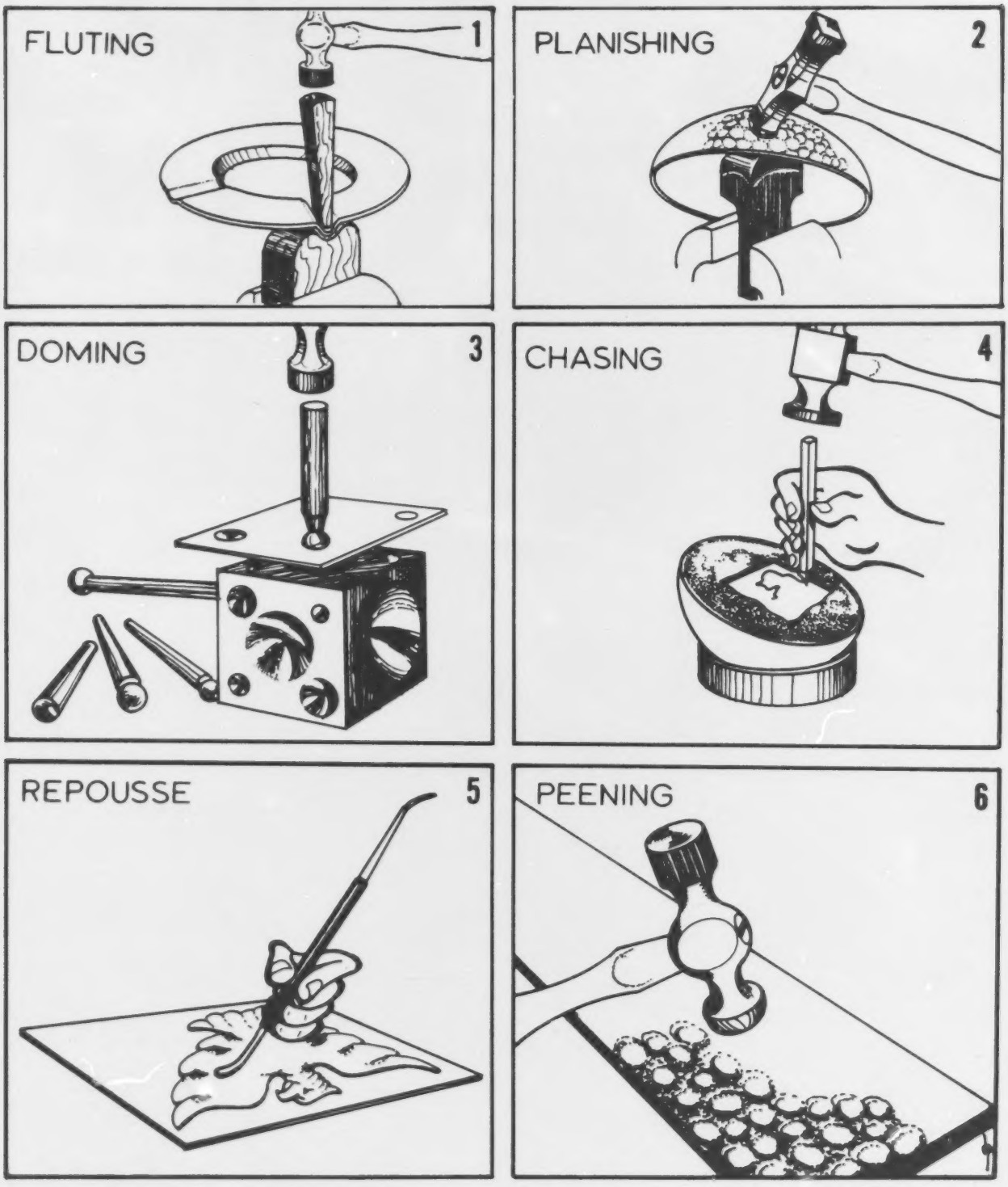
5. Cut silhouette in paper. Wet silhouette and base coat.



Press silhouette down flat. Dust contrasting enamel over entire surface. Carefully lift silhouette with tweezers allowing base coat silhouette to show through.

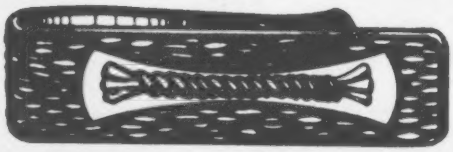
NOTE: After the base coat of enamel has been fired, gum cleaner is brushed on the surface and one of the methods described above is selected for surface decoration.

DECORATING TECHNIQUES ON METAL: Sample Related Information Sheet



MASS PRODUCTION: JEWELRY AND ART METAL

PRODUCT: Tie Clasp



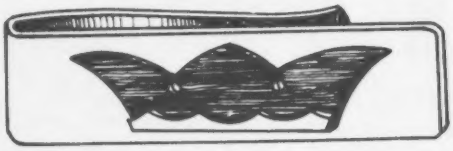
This product is a functional article that can be mass produced in a relatively short period of time. Because the item relates to good grooming, particularly as it affects neatness in dress, the value of the undertaking is increased.

The article can be produced rapidly and at low cost. Once the basic form has been determined, the decorations can be altered to meet varied tastes. Possibilities for decoration can range from adding a bezel and stone to sweat soldering an initial. Chemical treatment with liver of sulphur prior to finishing with lacquer is another possibility. Peening the surface will not only harden the metal, but also embellish it.

The organization of the assembly line for the mass production of this item can be easily adapted to accommodate similarly fabricated products such as money clips, pocket clips, and girls' hair clips which are modifications of the tie clasp design. Introducing these articles will expand the potential market if these products can be sold at the school fair or G.O. store.

Shaping sheet copper with a jeweler's saw

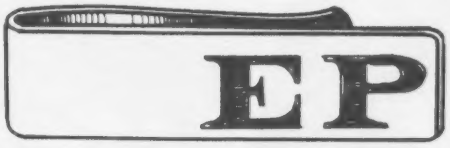
TIE CLASP: Alternate Design Ideas



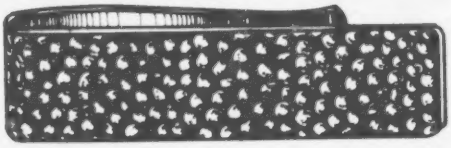
Overlay

Piercing

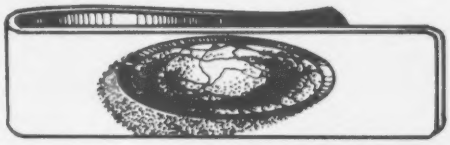
Etching



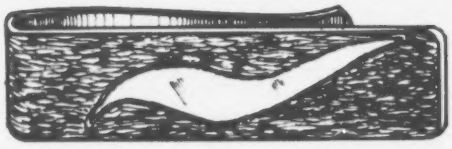
Engraving



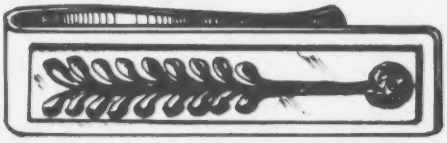
Ball Peen



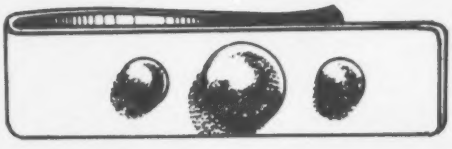
Stone with Bezel



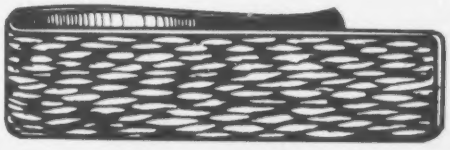
Chasing



Enameling



Doming



Straight Peen

OPERATION SHEET

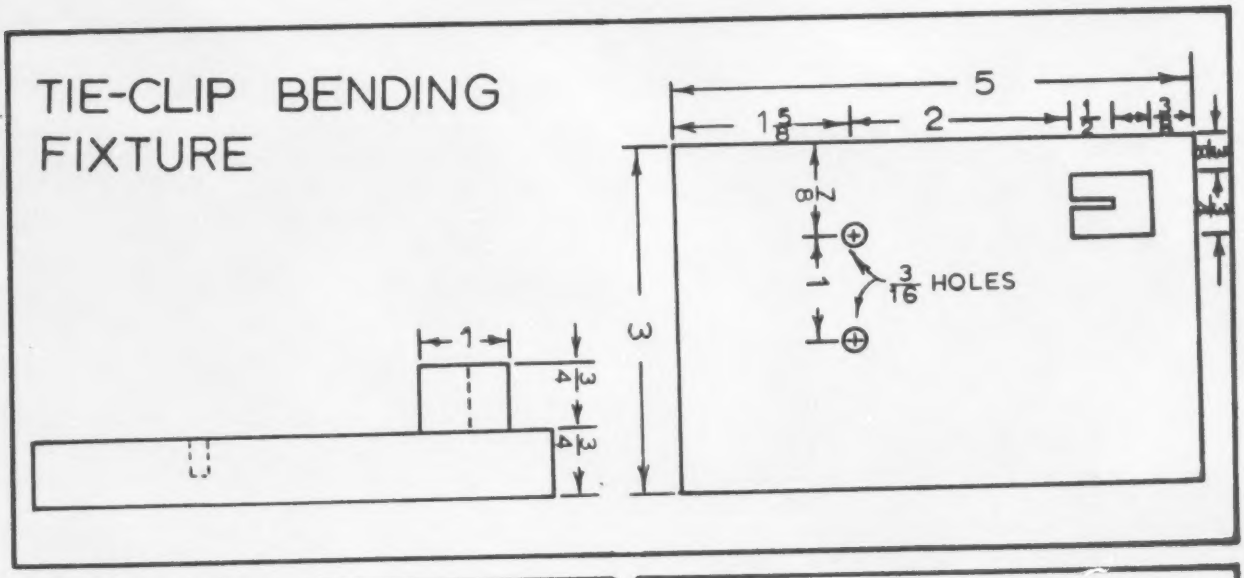
TIE CLASP

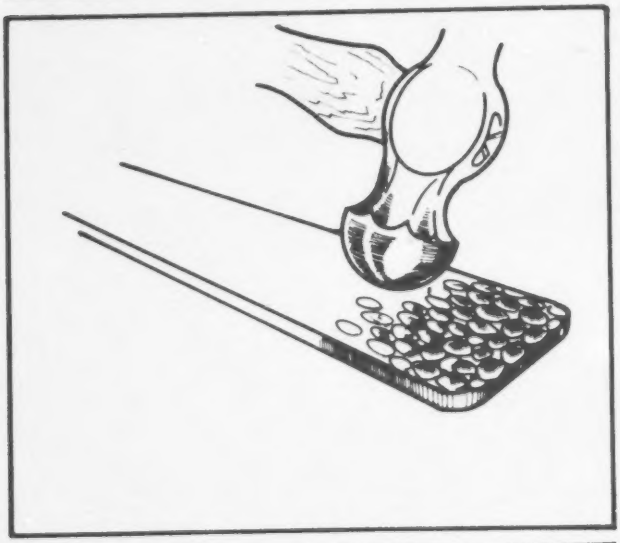
Sequence	Operation Description	Tools and Equipment
1	Cut blanks to size (⅜" x 3¾" x 18 ga.). Set stop gage.	Steel rule, squaring shears
2	Peen one surface of blank	Ball peen hammer, steel block
3	Remove sharp edges. Round corners slightlv. Clean surfaces.	File, steel wool, emery cloth
4	Make design pieces. (See braided wire construction below).	
5	Mark off flux area. Apply flux. Position braid on blank. Clamp in place. Apply heat and sweat solder	Flux, locking tweezer Soldering torch or propane torch
6	Clean and polish surfaces. Buff blank.	Steel wool, emery cloth, buffing wheel, rouge
7	Bend to final shape	Bending fixture
8	Apply finish	Lacquer
9	Final inspection	

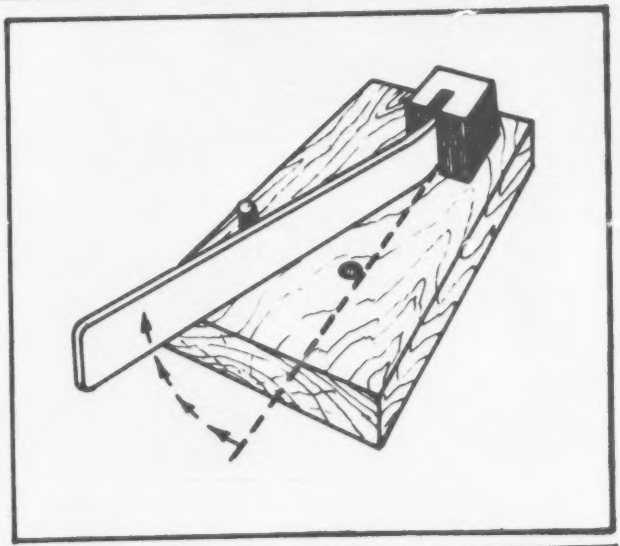
BRAIDED WIRE CONSTRUCTION

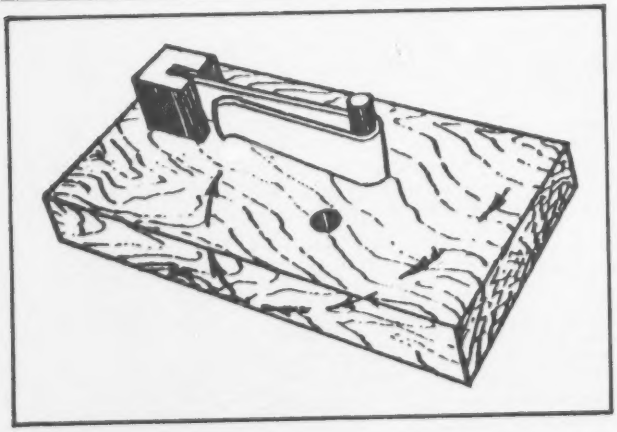
1	Cut 18 gage copper wire 2 feet in length	Steel rule, cutting pliers
2	Fold strand in half and place ends in vise	Bench vise
3	Using hand drill with hook (made from nail) pull wire taut and twist to a tight braid	Hand drill, nail
4	Start flattening braid	Steel block or anvil, Ball peen hammer
5	Using slip form rollers, form braid to desired shape and thickness	Slip form rollers
6	Clean one side of braid and apply flux Tin surface using a minimum amount of solder	Steel wool, flux Solder, soldering iron
7	Cut braid to desired lengths. Smooth ends of braid.	Cutting pliers, file.

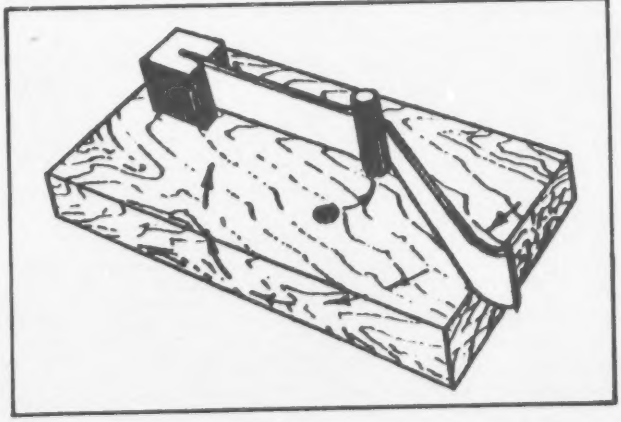
TIE-CLIP BENDING FIXTURE



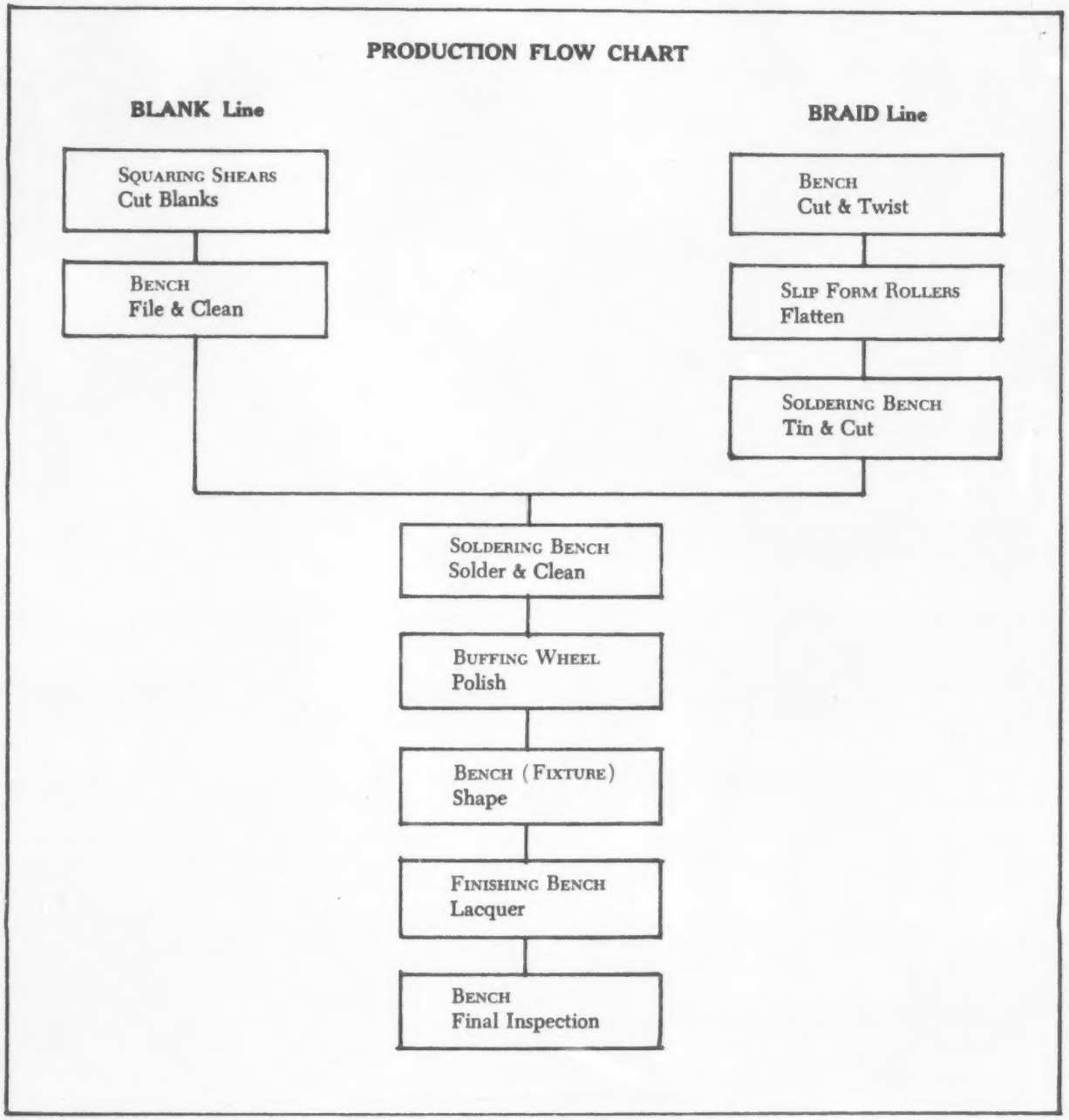








TIE CLASP


PRODUCTION FLOW CHART
BLANK Line
BRAID Line
Squaring Shears
Cut Blanks
Bench
File & Clean
Bench
Cut & Twist
Slip Form Rollers
Flatten
Soldering Bench
Tin & Cut
Soldering Bench
Solder & Clean
Buffing Wheel
Polish
Bench (Fixture)
Shape
Finishing Bench
Lacquer
Bench
Final Inspection

OCCUPATIONAL INFORMATION: Jewelry and Art Metal Area

JEWELER

TYPE OF EMPLOYMENT: Jewelers make rings, pins, necklaces, bracelets, and other jewelry by hand. They can create jewelry by setting precious and semi-precious stones in metal such as gold and silver. They also repair jewelry by soldering broken parts, making new parts, enlarging or reducing the size of rings, resetting stones, or restyling jewelry. Jewelers must be skilled in the use of files, saws, drills, dapping, carving, and chasing tools and know how to use a soldering iron and operate polishing machines.

WHERE EMPLOYED: The jeweler can work in manufacturing where possibilities for advancement exist; for example, where the jeweler can be promoted from a production jeweler to a shop supervisor. In retail stores, jewelers can become heads of sales departments or store managers. Some jewelry workers prefer to be self-employed and have established their own retail stores.

TRAINING: The jewelry trade is generally learned by either serving a formal apprenticeship or through informal on-the-job training while working for an experienced jeweler. Throughout the apprenticeship, training on the job is supplemented by trade school instruction in design, quality of precious stones, chemistry of metals, and other related subjects. A high school education is desirable for those seeking to enter the trade; courses in chemistry, physics, mechanical drawing, and art are particularly useful. Mechanical aptitude, finger and hand dexterity, and good eyesight are important.

Pin — Designed by John Prip

Neckpiece — Designed by Arline M. Fisch

Courtesy — Museum of Contemporary Crafts

SUGGESTED QUESTIONS: Jewelry and Art Metal

True or False

Directions: Place either a T or F in the column at the left of each question.

_____ 1. Beeswax may be used to help the cutting action of a jeweler's saw.

_____ 2. A jeweler's saw blade is placed in the frame with the teeth pointing away from the handle.

_____ 3. An electric grinder may be used to remove excess copper from a pin, pendant, or other piece of jewelry.

_____ 4. To keep polished metal from oxidizing, it is coated with lacquer.

_____ 5. The process by which metal is eaten away by chemical action is known as engraving.

_____ 6. A polishing wheel removes deep scratches in metal.

_____ 7. Handcrafted art metal pieces are usually mass produced.

_____ 8. Enameling is the process of applying fine grains of glass to metal; then fusing them to the metal at high heat.

_____ 9. Copper is a yellowish colored metal that looks like gold.

_____10. After using a jeweler's saw, rough edges on the metal can best be eliminated with a file.

_____11. Peening not only decorates the surface of metal, but also softens the area of the metal that is hammered.

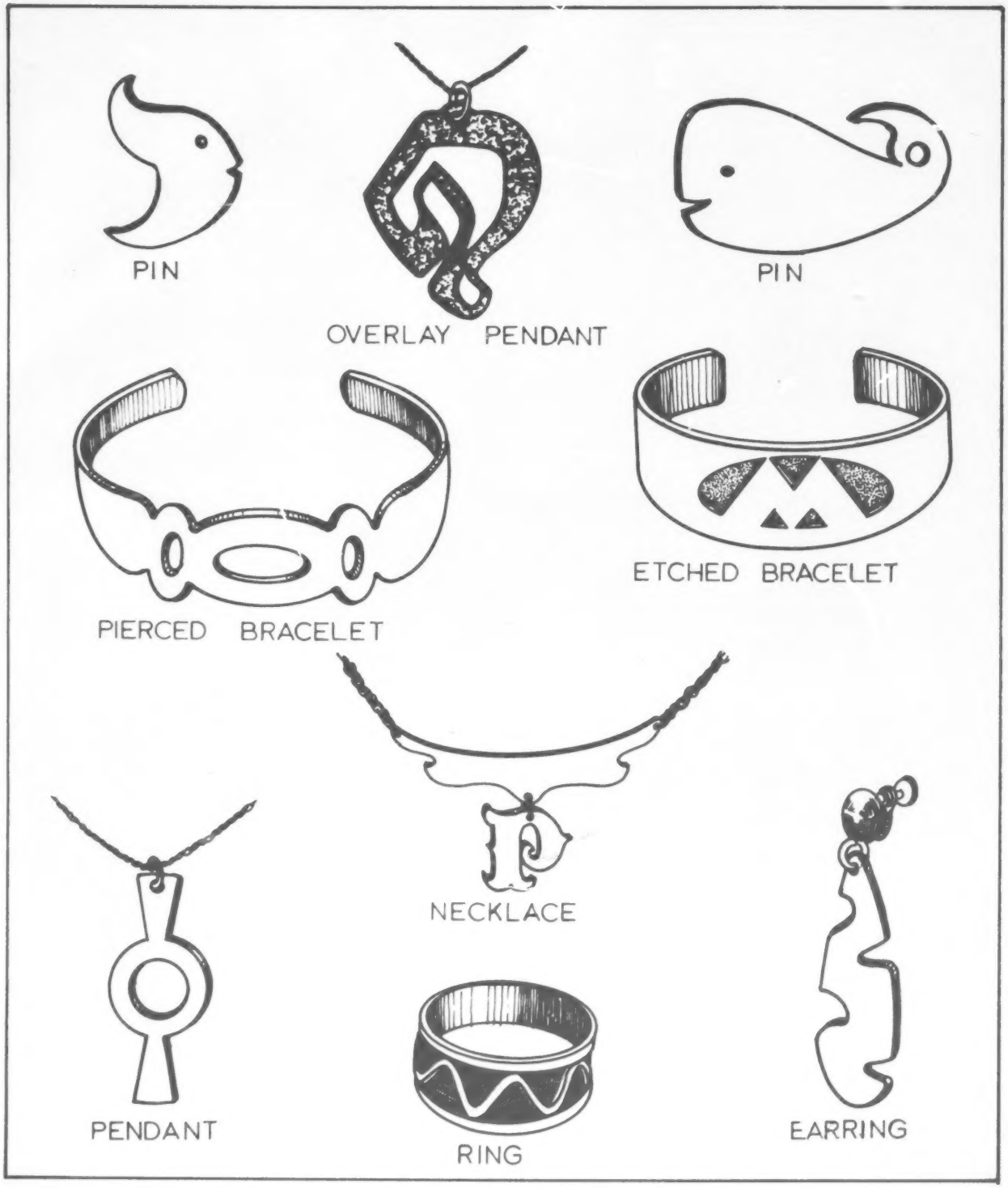
_____12. Metals are sometimes colored to give the effect of age and to add interest to the jewelry or art metal product.

_____13. When using the buffing wheel, it is considered good practice to polish plastics and metals on the same wheel.

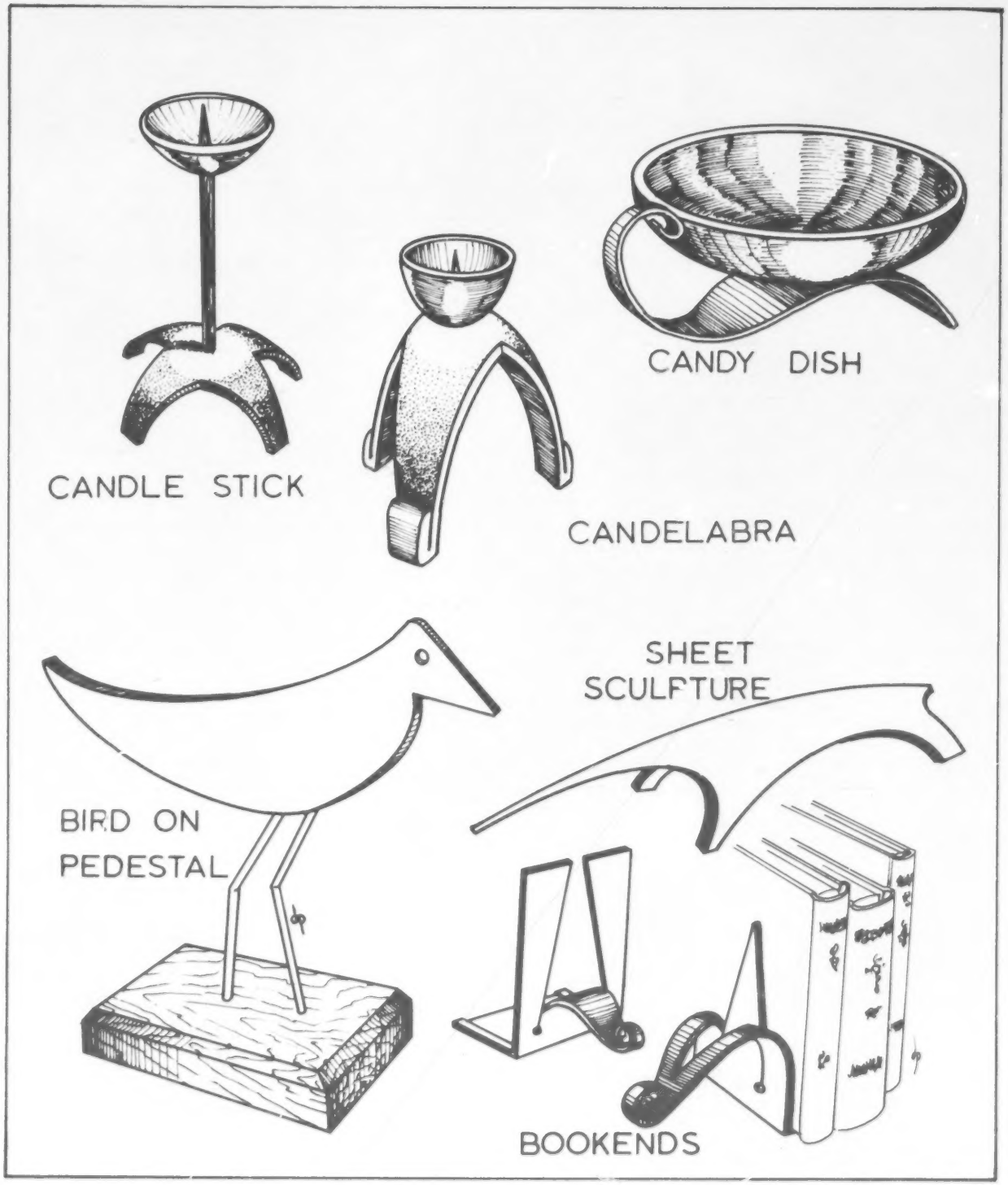
____14. Planishing removes blemishes and irregularities that have developed during the forming of a metal bowl.

_____15. As metal is being shaped, it becomes work-hardened and must be softened by the process of annealing.

JEWELRY: Alternate Product Ideas



ART METAL: Alternate Product Ideas



SELECTED RELATED MATERIALS

Jewelry and Art Metal

Books

Crawford, John *Introducing Jewelry Making*. New York: Watson-Guptill, 1969.

Franke, Lois E. *Handwrought Jewelry*. Bloomington, Ill.: McKnight & McKnight, 1962.

Hawkins, Leslie V. *Art Metal and Enameling*. Peoria, Ill.: Chas. A. Bennett, 1967.

Hughes, Graham. *Modern Jewelry*. New York: Crown Publishers, 1968.

Lynch, John. *Metal Sculpture: New Forms, New Techniques*. New York: Viking, 1968.

Pack, Greta. *Jewelry and Enameling*. Princeton: D. Van Nostrand, 1961.

Shoenfelt, Joseph F. *Designing and Making Handwrought Jewelry*. New York: McGraw-Hill, 1960.

Wiener, Louis. *Hand Made Jewelry*. New York: Van Nostrand, 1960.

Winebrenner, Kenneth D. *Jewelry Making as an Art Expression*. Scranton, Pa.: International Textbook, 1953.

Von Neumann, Robert. *The Design and Creation of Jewelry*. Philadelphia: Chilton Books, 1969.

Zechlin, Katherine. *Creative Enameling and Jewelry Making*. New York: Sterling, 1965.

Brochures and Pamphlets

Enameling on Copper and Other Metals. Thomas C. Thompson Co., 1539 Old Deerfield Road, Highland Park, Ill. 60035.

Metal Spinning for the Home Craftsmen. Boice-Crane Co., Toledo, Ohio 43606.

Manual for Buffing With Cloth Wheels. Divine Brother Company, 200 Seward Ave., Utica, N. Y. 13503.

Flatware and Hollowware. Retail Jewelers of America, Inc., 1025 Vermont Ave., Washington, D.C. 20005.

The Golden Touch (Career Opportunities) Retail Jewelers of America.

Motion Picture Films

Beauty in Precious Metal (22 min). Association–Sterling Films, 43 West 61 St., New York, N.Y. 10023.

A visit with the master craftsmen who create rings. The fascinating laboratory and factory processes necessary in the manufacture of these jewelry items are depicted.

Design in Silver (11 min). Center for Library, Media & Telecommunications, 131 Livingston St., Brooklyn, N.Y. 11201.

Expert craftsmanship and a feeling for fine design are combined to show the processes in jewelry making.

Metal Craft (11 min). Center for Library, Media & Telecommunications, 131 Livingston St., Brooklyn, N.Y. 11201.

Reveals skilled craftsmen working with pewter and bronze. Includes demonstration of how to make a bowl of spun pewter, a hammered bronze bowl, a molded pewter candlestick, and a pewter jewel box.

BENCH and MACHINE METAL

The bench and machine metal unit constitutes one of the most important areas of the metalworking program. Practically every product made in this country contains metal parts or is manufactured by machines that are made of metal parts. Many of these metal components are shaped to precise dimensions by skilled workers who are proficient in the use of a variety of tools and machines. From the standpoint of job opportunities, machine workers make up the largest occupational group in the metalworking trades.

In the metalworking shop, the student can be introduced to some of the basic concepts and skills relating to hand tool use and machine tool operation. The pupil is in a position to appreciate the advantages of the tool. The student has only to use a hand drill at the bench and then compare the relative ease of drilling at the drill press to appreciate the power driven machine's value and contribution to society.

The role of accuracy must be stressed because metal parts are often interchangeable and can be easily assembled for mass production purposes. The use of measuring tools, such as the micrometer and gages to determine acceptable tolerances, should be brought to the pupils' attention so that they can understand quality control techniques and appreciate the benefits that are derived from quality production.

SPECIAL MACHINING PROCESSES

While the students in the shop will be introduced to the fundamentals of machine operation, they should also be cognizant of the significant developments that are occurring in the metalworking industry that are affecting traditional production techniques. Special machining processes include:

Numerical Control (NC)

A method of accurately controlling the movement of machine tools by a series of programmed numerical data which activate the motors of the machine tool.

Electrochemical Machining (ECM)

A process which uses electrical and chemical energy as cutting tools. This method machines metal easily regardless of the work hardness and is characterized by its chipless operation.

Electrical Discharge Machining (EDM)

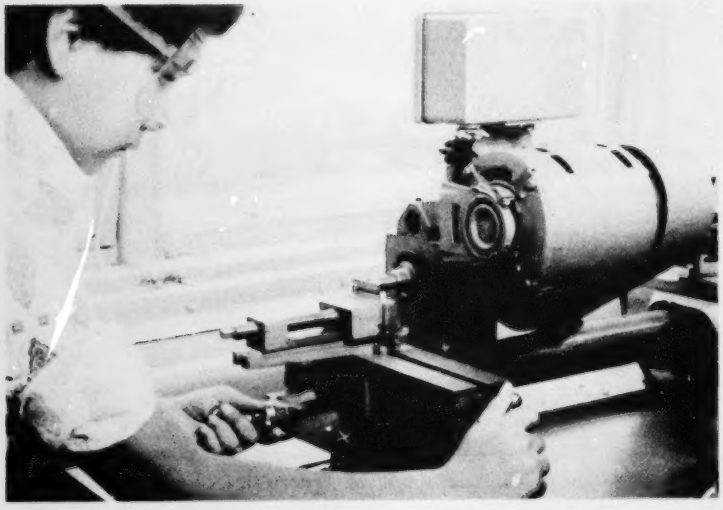
A process that is based on the principle of removing metal by an electric spark. Metal is removed by means of an electrical discharge of short duration and high current density that is emitted between the tool and the work piece.

Powder Metallurgy

A process of producing metal parts by blending powdered metals, compressing the powders in a die which is the shape of the part to be produced, and finally, subjecting the shaped form to high temperatures which cause the metal particles to sinter together and form a solid part.

Turning on the metalworking lathe

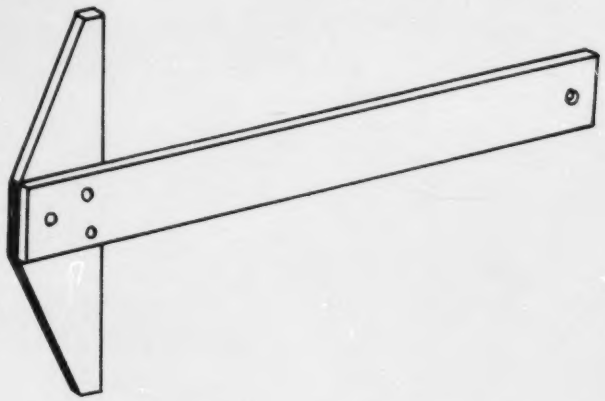
Drilling on drill press with work clamped in a Float-Lock Safety Vise



Operating a milling machine

UNIT PRODUCTION: BENCH AND MACHINE METAL

PRODUCT: T Square

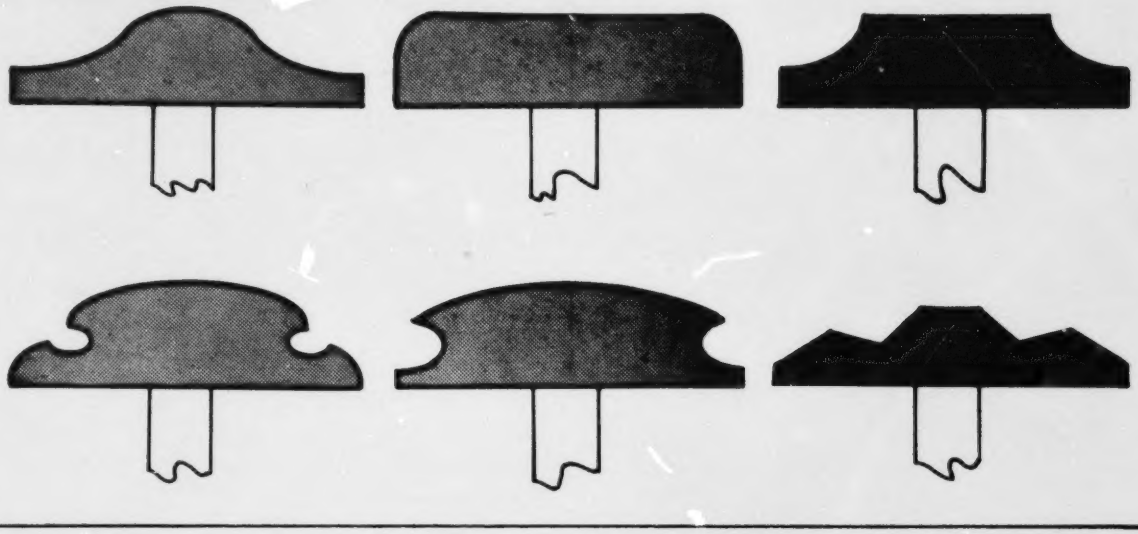


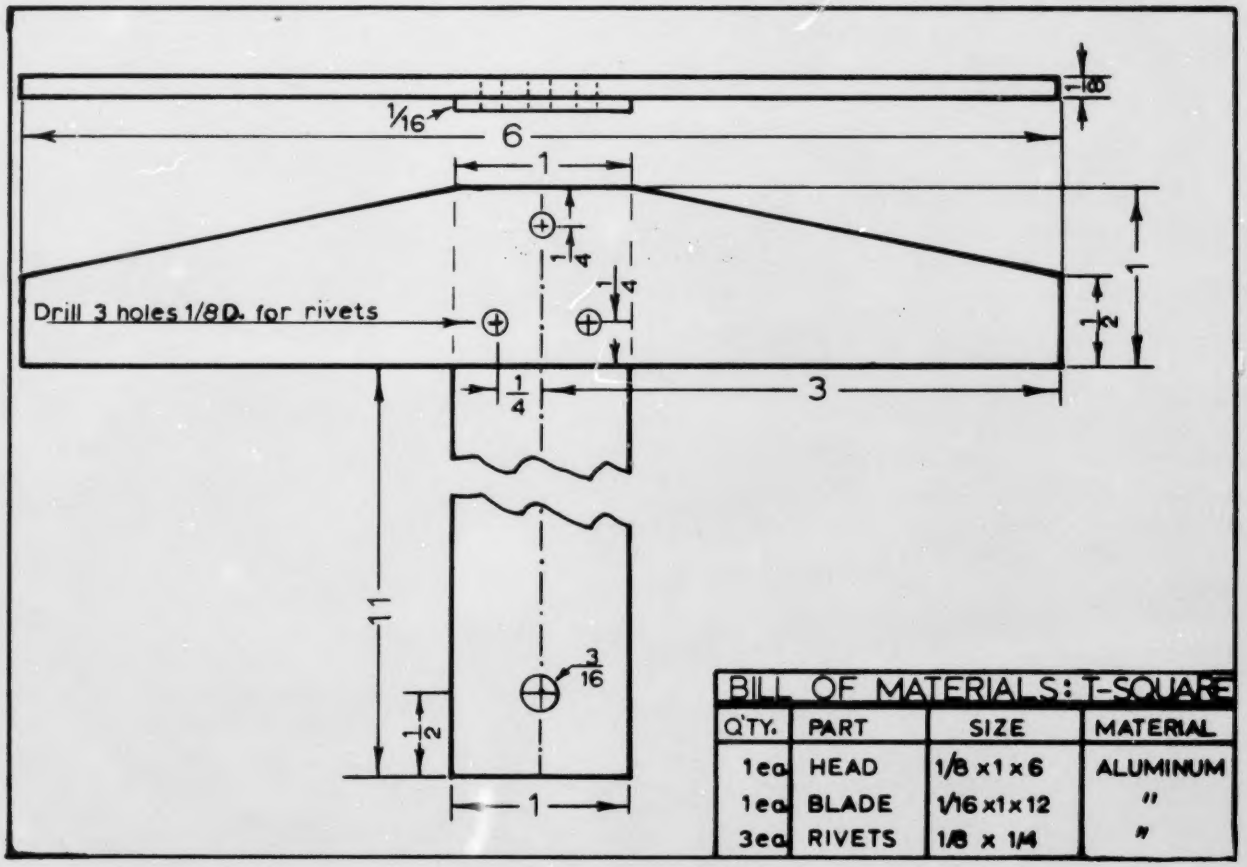
This product can be used by the student in the metal-working shop or in the home in the development of working drawings that relate to those articles being fabricated in the shop. Basic bench and machine tools are required in its construction.

The product design can be altered by changing the shape of the head of the T square. Anodizing permits the addition of color and can enhance the appearance of the item. Aluminum is a suitable metal because of its excellent working characteristics. Introducing aluminum in the bench and machine area allows the student to experience and learn about the properties and application of this important metal.

Reducing the diameter of cylindrical stock with the material held in a 3 jaw Universal Chuck. Turning, boring and thread-cutting are some of the operations that can be done on this engine lathe

T-SQUARE — Alternate Design Ideas





BILL OF MATERIALS: T-SQUARE

Q'TY.	PART	SIZE	MATERIAL
1ea	HEAD	1/8 x 1 x 6	ALUMINUM
1ea	BLADE	1/16 x 1 x 12	"
3ea	RIVETS	1/8 x 1/4	"

OPERATION SHEET

T-SQUARE

Sequence	Operation Description	Tools and Equipment
HEAD CONSTRUCTION		
1	Pre-cut stock to 6⅛" long	Vise, steel rule, hacksaw
2	Apply layout fluid on one side only. Select design and transfer to metal.	Layout fluid, brush, template scriber
3	Locate (3) holes and center punch using template. Drill (3) holes ⅛" dia. Remove burrs.	Template, center punch, ball peen hammer ⅛" dia. twist drill, drill press, vise file
4	Countersink holes, one side only	Vise, vise jaws, countersink, hand drill
5	Cut excess material. File to shape.	Hacksaw, vise, file
6	Draw file and polish with emery cloth	File, vise, emery cloth
BLADE CONSTRUCTION		
1	Pre-cut stock to 12⅛" long	Vise, steel rule, hacksaw
2	Apply layout fluid to both ends. Lay out guide lines for squaring ends.	Layout fluid, brush, steel square scriber
3	File ends square	Vise, vise jaws, square
4	Locate ⅛" dia. rivet hole and 3/16" dia. hole. Drill ⅛" dia. and 3/16" dia. holes. Remove burrs.	Rule, scriber, ball peen hammer, center punch, drill press, vise ⅛", 3/16" dia. twist drills, file
5	Draw file and polish	Emery cloth, file, vise, vise jaws
ASSEMBLY		
1	Place head and blade in proper position and rivet	Bench, steel block, ball peen hammer
2	Place components in squaring fixture.	squaring fixture
3	Drill remaining ⅛" dia. holes through blade using drilled holes in head as guide. Remove burrs	Drill press, ⅛" dia. twist drill File
4	Complete riveting operations while head is square to blade	Bench, steel block, ball peen hammer, square
5	Polish product	Emery cloth, steel wool
6	Inspect completed product	

DEMONSTRATION LESSON PLAN

Topic: Drill Press

Aim: To introduce basic operations and concepts relating to the use of the drill press in the school shop and industry.

Preparation:

Drill press	Twiwt drills	Goggles	Oil can
Chuck key	Countersink	Drill vise	Brush
Hand drill	Counterbore	Parallels	Metal stock (center-punched in advance)
Drill jig	Reamer	C clamp	

Visual Aids:

Samples of work produced on the drill press: drilled, tapped, reamed, bored, countersunk, counterbored holes.

Motivation:

Student demonstrates the hand method of drilling steel. What other method would save time and effort?

Presentation:

1. Identify main parts--drill press nomenclature.
2. Tighten twist drill in chuck.
3. Hold work securely in drill vise.
4. Adjust table to proper height and position.
5. STRESS SAFETY: GOGGLES, LOOSE CLOTHING, CHUCK KEY, CIAMP VISE TO TABLE, SAFE FEEDS AND SPEEDS, REMOVE CHIPS WITH BRUSH (MACHINE STOPPED)
6. Demonstrate operations--drilling, counterboring, countersinking.
7. Correlate: Cutting edge based on wedge, feeds and speeds depend on hardness of metal and toughness of cutting tools, R.P.M. pulley sizes.
8. Compare drill press in shop with the drilling machines in industry. Types--bench drill, gang drill, multiple spindle drill, radial drill.
9. Indicate role of numerical control, use of drilling jigs, use of measuring tools and gages for inspection purposes.

Summary:

Names and function of important parts of drill press.
Operations that can be performed on drill press. Safety regulations.

Application:

Students operate drill press in fabrication T-square and bicycle lock.

Assignment:

Distribute notebook sheets depicting drill press. Students write in names of various parts.

References:

Ludwig, Oswald A. and McCarthy, Willard J. Metalwork Technology and Practice. Unit 27, "Drilling Machines;" Unit 28, "Holding Work for Drilling;" Unit 29, "Drilling."

DEMONSTRATION LESSON PLAN

Topic: Metal Lathe Operations

Aim: To introduce basic operations and concepts relating to shaping stock on the lathe in the school shop and industry.

Preparation:

Lathe	3 Jaw chuck	Center drill	Drill chuck
Tool bits	Chuck key	Twist drill	Metal stock
Micrometer	Steel rule	Outside caliper	Oil can

Visual Aids:

Samples of work formed on lathe: tapered, knurled, threaded, etc.
Photographs of a variety of lathes used in industry.

Motivation:

Display a machine screw. Where are these used? Why must they be accurately made? How is the metal removed to form the desired shape?

Presentation:

1. Identify main parts--lathe nomenclature.
2. Clamp work in three jaw universal chuck.
3. Adjust tool bit in tool post.
4. STRESS SAFETY: GOGGLES, LOOSE CLOTHING, CHUCK KEY, FEEDS & SPEEDS.
5. Demonstrate operations: turning, facing, centerdrilling, drilling.
6. Correlate: Cutting edge based on wedge; speeds and feeds based on metal's hardness and tool bit's toughness. Lathe is most important machine tool.
7. Compare lathe in shop with those in industry: Types--bench, engine, turret, screw machines.
8. Indicate role of numerical control, interchangeability of parts. (standardization)
   Use of measuring tools and gages for inspection purposes.

Summary:

Names and function of important parts of lathe.
Operations that can be performed on lathe. Safety regulations.
Reasons why lathe is most important machine tool.

Application:

Students take trial cuts in facing and turning stock.
Students use lathe during mass production of bicycle lock.

Assignment:

Distribute printed sheets depicting lathe. Insert names of parts.

References:

J.L. and Lindbeck, John R. I.A. Metalwork. Unit 29, Ludwig, Oswald A. and McCarthy, Willard J. Metalwork Technology and Practice. Unit 57, "The Lathe and Lathe Operations" ''. 462-293.

RELATED LESSON PLAN

Topic: Automation

Aim: To introduce basic concepts relating to automation and numerical control in the metalworking industry

Preparation:

Samples of metal parts produced by automated process
Photographs of numerical control equipment
Simplified chart of NC operational sequence
Motion picture depicting automation in manufacture of metal parts

Motivation:

Show a tin can. What method was used to make the container, fill and to seal the contents?

Presentation:

1. Define "automation"
2. Cite examples of automated processes in metalworking industries, foundries, automobile manufacturing
3. Discuss advantages and disadvantages of automation: improved product quality, uniformity, increased production, reduces drudgery by eliminating repetitive manual labor
4. Introduce NC as one form of automation
5. Explain terms: feedback, output and input
6. Indicate sequence of operations in use of NC machine tools
   a. Engineers translate part dimensions, cutter shapes, cutting paths, operation sequence into numbers or codes representing numbers
   b. Numbers are punched on cards or tapes which are inserted into electronic or mechanical devices that translate numbers into motions or actions such as drilling or milling
   c. Machine tool operator simply installs the tools, inserts and removes the work piece and changes the tapes or cards

Summary:

What is automation?
What are three contributions that automation makes to society?
Describe sequence of NC process.

Assignment:

Draw a sketch of the main components that make up the NC system.
Write a report explaining how automation raises the standard of living in this country.

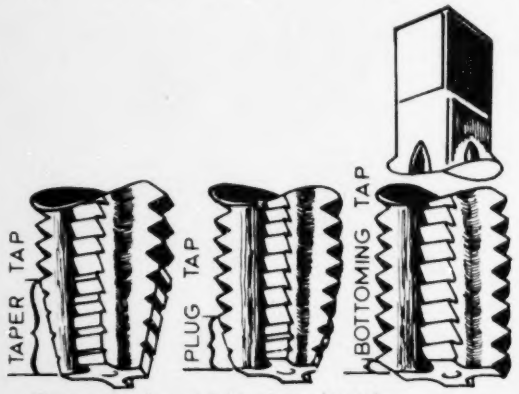
References:

Ludwig, Oswald A. and McCarthy, Willard J. Metalwork Technology and Practice. Unit 62, "Automation and Numerical Control Machining" pp. 582-606.

Krar, S.F., Oswald, J.W., and Amand, J.E. Technology of Tools. Chapter 17, "Special Processes" pp. 468-477.

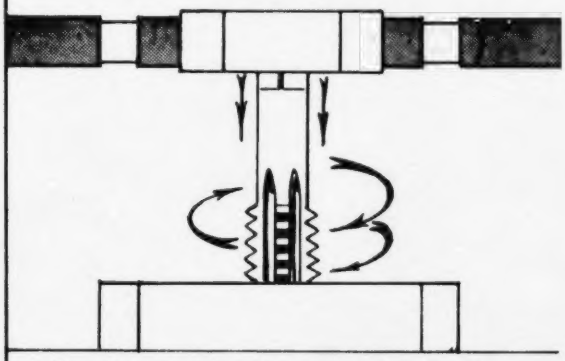
CUTTING A THREAD WITH A TAP: Sample Instruction Sheet

1 Select proper size tap and tap wrench.



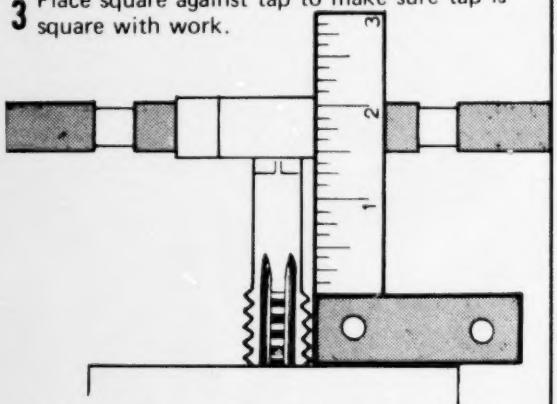
Taper tap is used to start thread.

2 Start tap by pressing down and turning tap wrench in clockwise direction.



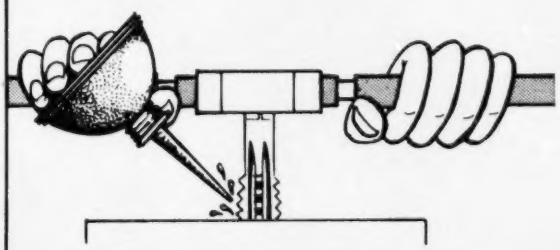
Metal stock clamped parallel with bench.

3 Place square against tap to make sure tap is square with work.



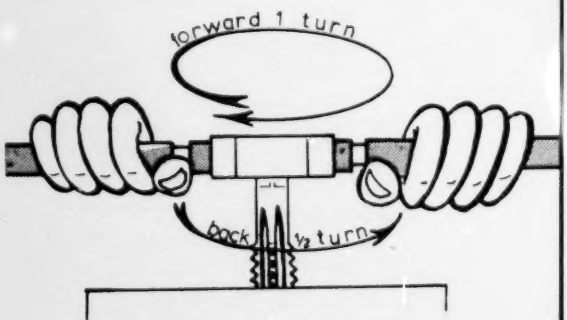
If tap is not square to work, back it out out of hole, straighten it; begin again.

4 Apply proper lubricant.



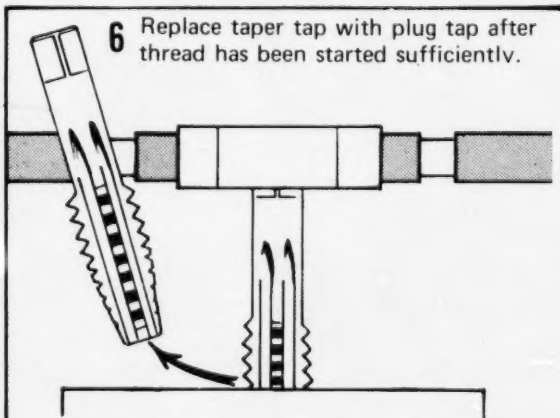
Oil reduces wear on cutting edges of tap and drains chips.

5 Cut threads by turning tap wrench. For each complete turn, back off a half turn.



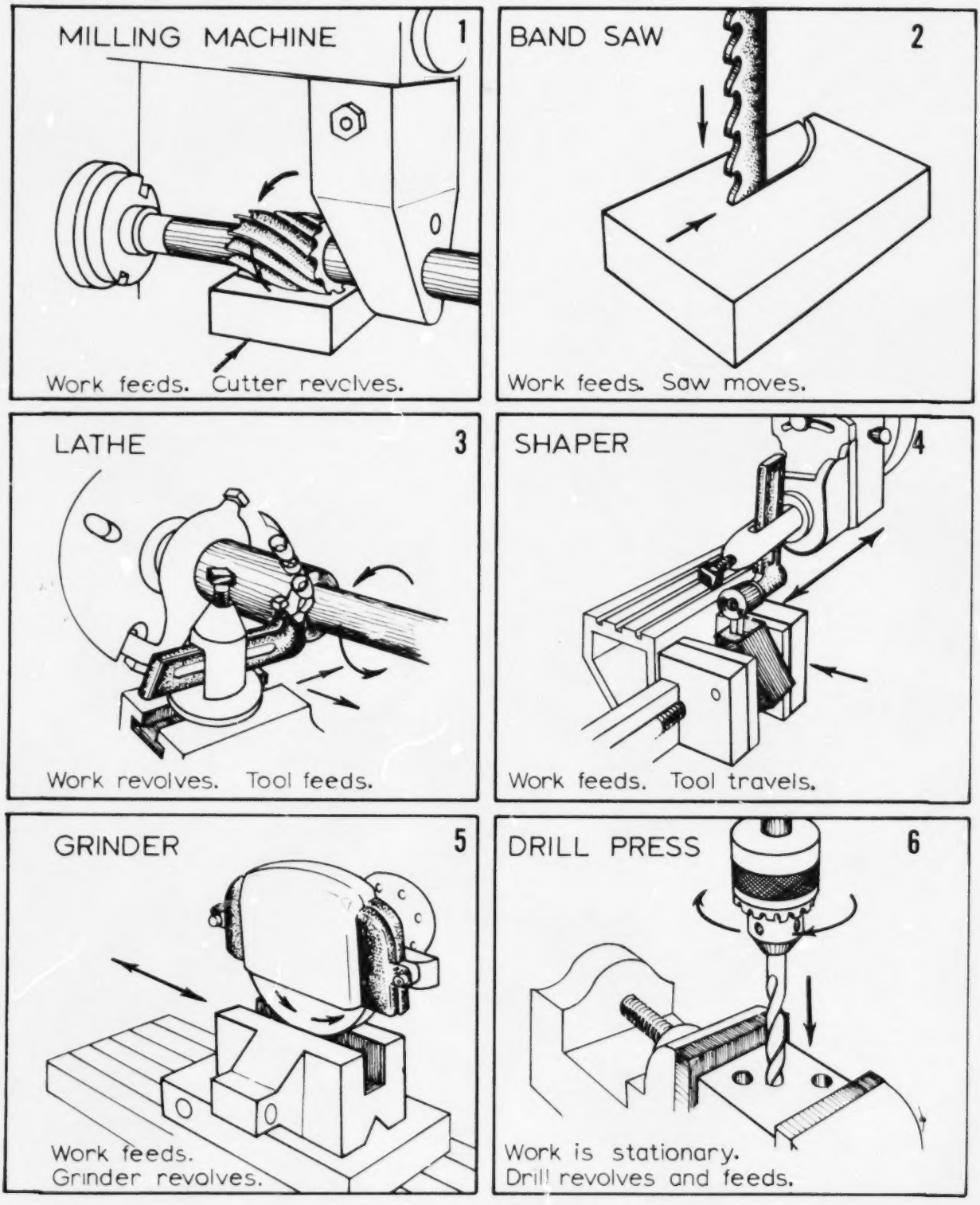
Reversing direction breaks the chip.

6 Replace taper tap with plug tap after thread has been started sufficientlv.

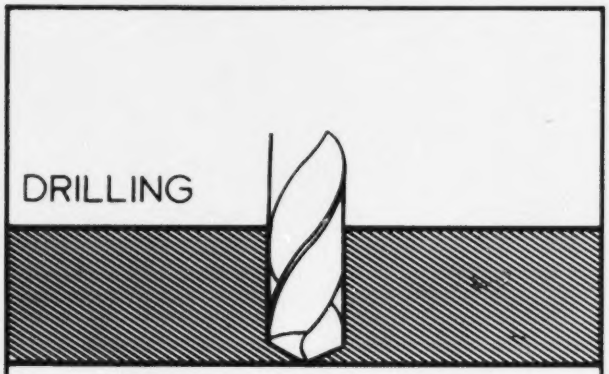


Use bottoming tap for blind holes.

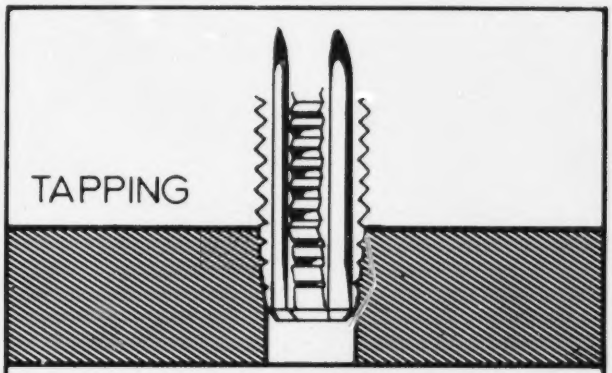
METAL CUTTING MACHINES: Sample Related Information Sheet



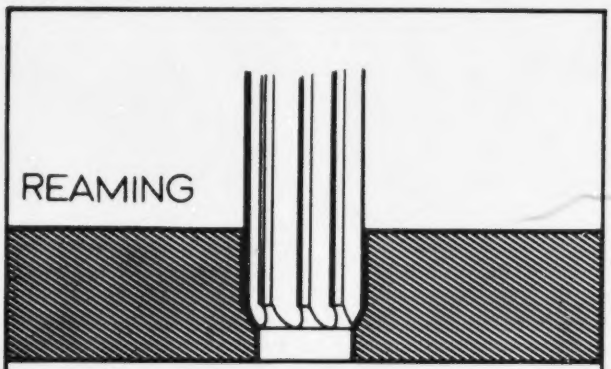
DRILL PRESS OPERATIONS: Sample Related Information Sheet



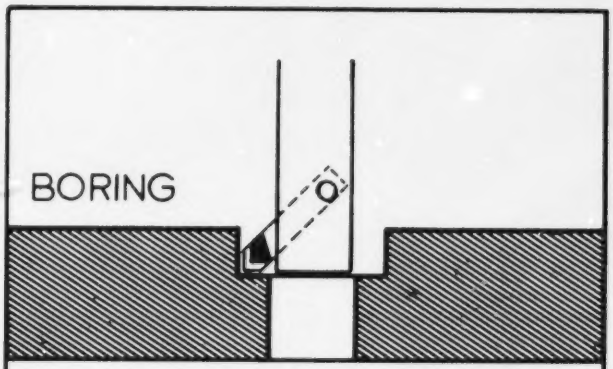
1. Drilling a hole with a twist drill.



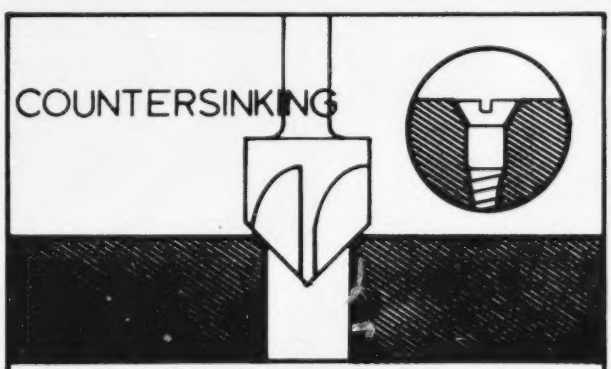
2. Cutting screw threads on the inside of a hole using a tap.



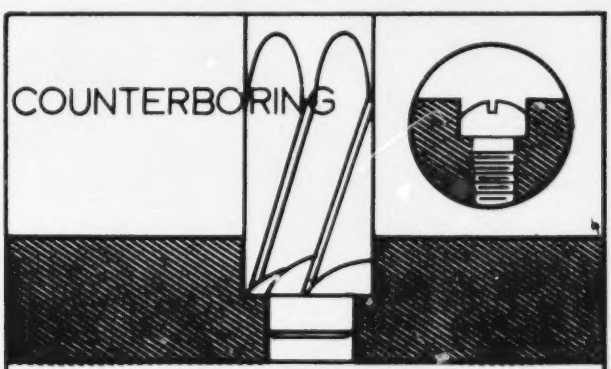
3. Reaming produces an accurately machined and smoothly finished hole.



4. Boring produces a very straight and accurate hole when the twist drill is not available in larger diameters.



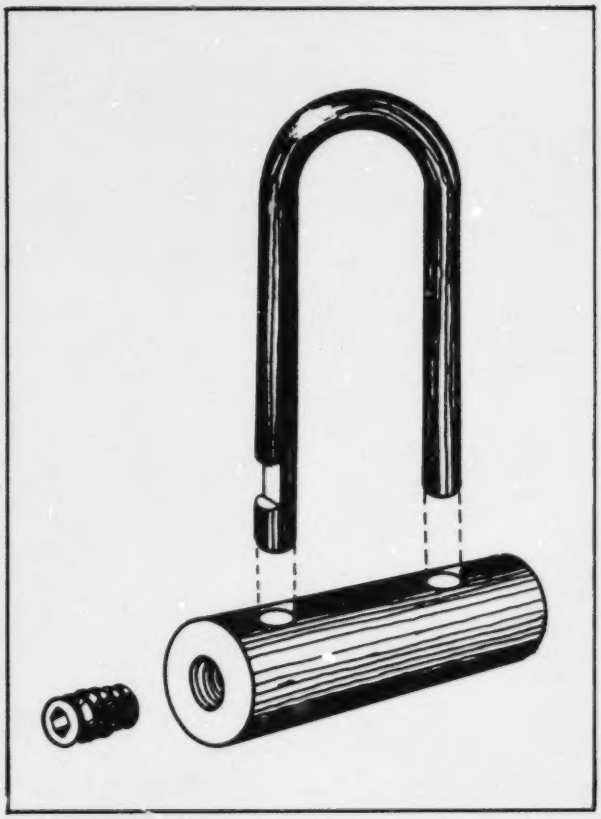
5. Countersinking produces a cone shape hole to fit the head of a flat head screw.

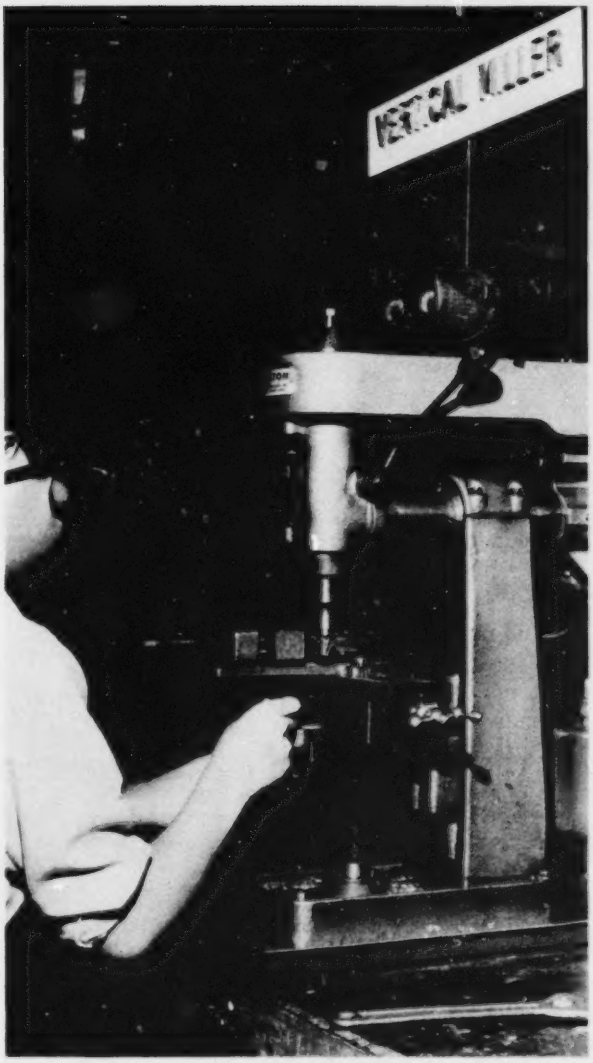


6. Counterboring enlarges the top of a hole to fit the head of a fillister head screw.

MASS PRODUCTION:
BENCH AND MACHINE METAL

PRODUCT: Bicycle Lock

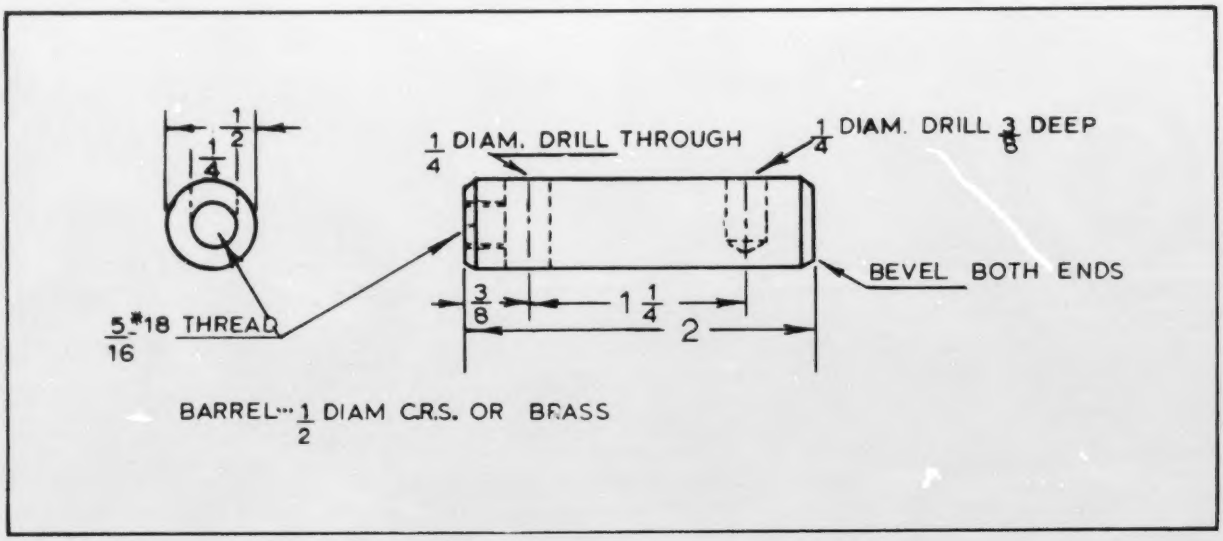


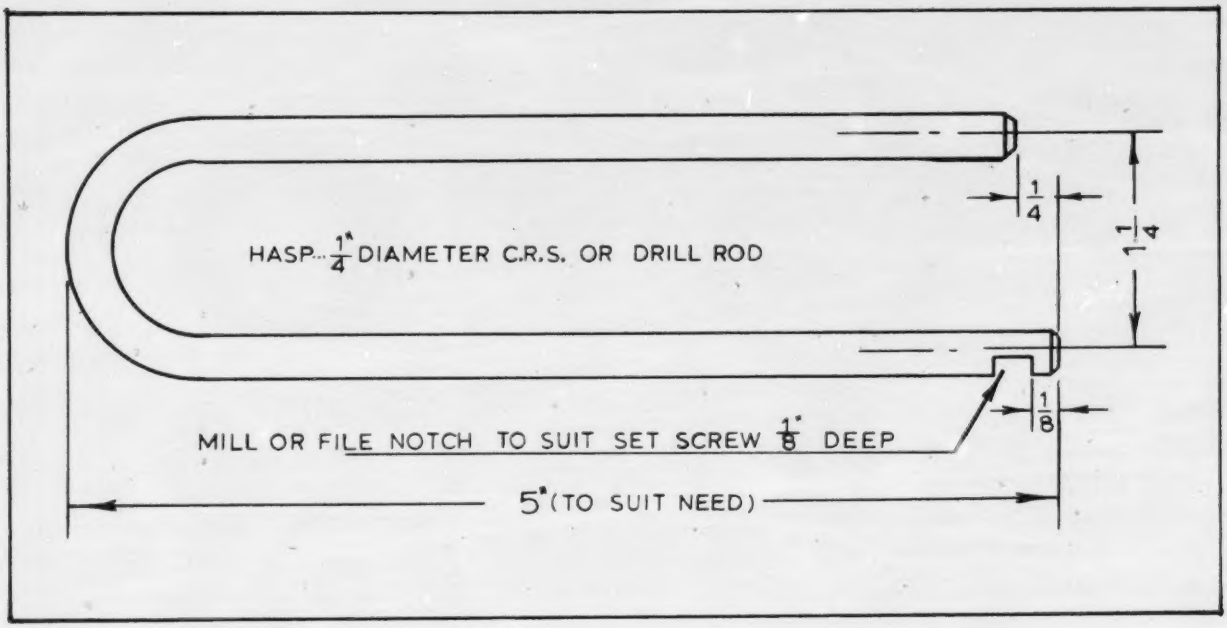


This mass production activity encompasses a variety of hand and machine operations. The product that emanates from the assembly line has strong student appeal because it is related to student interest. The basic design can be modified by lengthening the hasp and the type of locking arrangement that is used. A small allen wrench serves as the "key" to lock and unlock the device. Another design change is possible by drilling through the ⅜" deep, ¼" diameter hole on the barrel, and elongating the non-locking leg of the hasp. Peening the end of the longer leg, after it has been inserted through the hole, will prevent its removal from the barrel.

Polishing, knurling, or dip coating the barrel with plastics will add to the attractiveness of the product. The application of jigs and fixtures illustrates the value of using labor saving methods.

BICYCLE LOCK





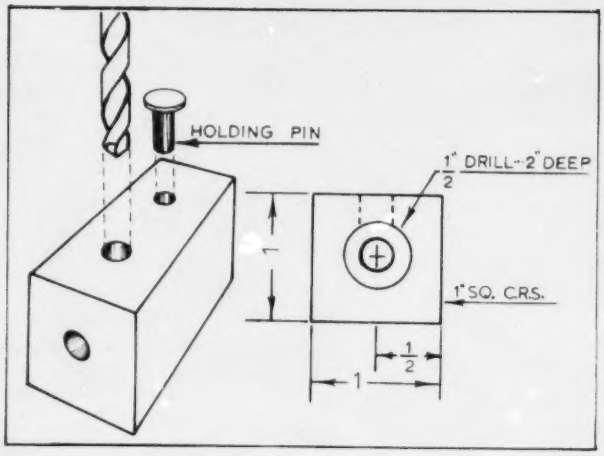
SCALE: Full Size

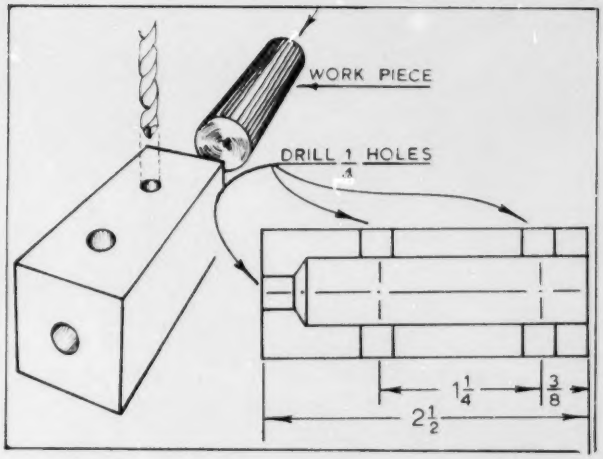
OPERATION SHEET

BICYCLE LOCK

Sequence	Operation Description	Tools and Equipment
BARREL CONSTRUCTION		
1	Face and turn stock to ½" dia. x 2¼" long	Lathe, universal chuck, rule, caliper
2	Cut off stock 2" long with cut-off tool. (Break corners with mill file when cut-off tool is halfway through stock)	Cut-off tool, rule, mill file
3	Drill (3) ¼" dia. holes at drill press using drill jig	Drill press, ¼" dia. drill, drill jig
4	Clamp barrel in vise and remove burrs by breaking corners with countersink mounted in hand drill	Vise, hand drill, vise jaws, countersink
5	Cut threads in end hole with 5/16 - 18 NC tap	Vise, 5/16 - 18 NC tap, tap wrench, oil
6	Polish barrel. Inspect.	Emery cloth
HASP CONSTRUCTION		
1	Cut ¼" dia. stock to 11" length. File ends square.	Vise, rule, hacksaw, file, square
2	Lay out bend line and form hasp to "U" shape	Diacro or Hossfeld Bender
3	Cut legs to required length.	Hacksaw, rule
4	File notch 1/16" deep in hasp	Vise, rule, scratch awl, square or rat tail file
5	Polish and inspect	Emery cloth
ASSEMBLY		
1	Assemble components with Allen Head Screw 5/16 - 18 x 5/16" long	Allen wrench
2	Peen longer leg of hasp to prevent removal of barrel	Vise, ball peen hammer
3	Final inspection. Test lock.	Allen wrench

BICYCLE LOCK: Drilling Fixture





BICYCLE LOCK

PRODUCTION FLOW CHART

BARREL Line

- LATHE — Turn & Face
- DRILL PRESS: — Drill Holes
- BENCH — Thread Holes
- BENCH — Remove Burrs
- BENCH — Polish & Inspect

HASP Line

- BENCH — Cut Stock
- BENCH — Bend "U"
- BENCH — Cut Legs
- BENCH — Notch & File
- BENCH — Polish & Inspect

- BENCH — Assemble
- BENCH — Peen
- BENCH — Final Inspection

METAL MOLDMAKING FOR PLASTICS PRODUCTS

Introducing plastics as a supplementary phase of the metalworking program adds an important dimension to the metalworking course. Students should be cognizant of the close relationship between plastics and metals. Synthetic materials are making inroads into the traditional applications of metals. Plastics are not only competing with metals but, in many cases, replacing them at an ever increasing rate in the fields of transportation, building construction, and packaging. Another reason for including plastics in the shop program is that the metalworking equipment – tools and machines – are used in fabricating plastics in such operations as turning, facing, drilling, filing, sawing, etc. The role of plastics in the course becomes more obvious when it is realized that the molds used in the plastics industry are constructed from metal so as to withstand the high temperatures and pressures that are required.

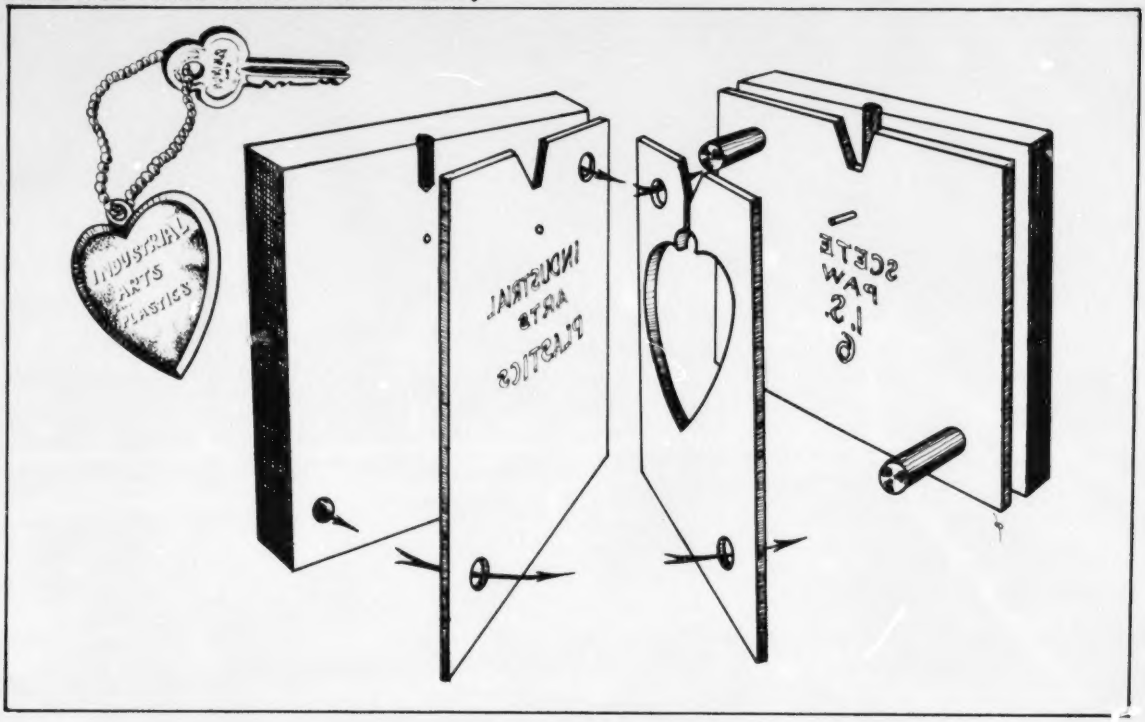
Moldmaking is an integral part of the bench and machine areas within the metalworking industry, and the introduction of basic concepts can help meet the exploratory aims of the course. Molds that are needed for the injection molding of plastics products in the school shop are relatively easy to construct. By employing one or more laminations of nonferrous plates that are sandwiched between two steel backup blocks, many small plastics items can be produced. The laminations contain the layout of the desired shape which is then cut out with the jeweler's saw or jig saw. Use of an engraving machine permits the addition of lettering or decorations on the plastics item.

In the shop, plastics can be combined with metal in the fabrication of the product. For example, small plastics items can be injection molded and then assembled with metal components as is done in industry. It is also possible to vary decorations by inlaying plastics in small metal objects. This can be accomplished by piercing the object, for example, a tie clasp, before it is bent to shape, placing the object or a portion of the article into a mold designed for the inlay, and forcing the plastics into the cavity of the metal object. Upon cooling, the plastics surface can be finished by filing, polishing, and buffing.

By making test runs with the injection molder, the students are in a position to compare the characteristics of plastics with metals. After they have used such materials as polyethylene or polypropylene, the properties become apparent. Students can then make rational judgments concerning those characteristics of metals and plastics that are to be considered in the design of a product.

Components of a steel mold used for injection molding. Note — Reversed lettering on engraved plate

PLASTICS PRODUCTS: Mold Assembly



OCCUPATIONAL INFORMATION: Bench and Machine Metal Area

MACHINIST

TYPE OF EMPLOYMENT: Machinists set up and operates most types of machine tools. They possess a wide knowledge of shop practice and the working properties of metals. Their understanding of what the various machines can accomplish enables them to transform metal stock into intricate parts meeting precise specifications. As skilled workers, they plan and carry through all operations needed in turning out machined products. All-around machinists select the tools and materials for each job and plan the cutting and finishing operations in order to complete the finished work according to blueprint specifications. They make standard shop computations relating to dimensions of work, tooling, feeds and speeds of machining. After completing the machining operations, they may finish the work by hand, using files and scrapers, and then assemble the finished parts with wrenches and screwdrivers.

WHERE EMPLOYED: Some machinists work in production departments of metalworking factories where large quantities of identical parts are produced; others work in machine shops where a limited number of varied products are made. Most large factories employ all-around machinists to keep mechanical equipment operating. In addition, some machinists also become self-employed by opening their own machine shops.

TRAINING: While an apprenticeship program is considered the best way to learn this trade, many machinists have qualified without the apprenticeship by learning the trade through several years of varied experience in machining jobs. An individual desiring to be a machinist should be mechanically inclined and temperamentally suited to doing highly accurate work that requires concentration as well as physical effort. A high school or vocational school education is desirable. Courses in mathematics, physics, and some knowledge of electronics and hydraulics are useful.

Promotional opportunities are available to machinists. Many advance to supervisor or other higher paying jobs. With additional training, some become tool and die makers or advance into other technical jobs in machine programming and tooling.

Locating steel blade of screwdriver in bottom half of mold before top of mold is assembled in preparation for injection molding

SUGGESTED QUESTIONS: Bench and Machine Metal

1. Tool steel can be hardened by:
   a) annealing
   b) heating and cooling quickly
   c) hammering
   d) heating and cooling slowly

2. Screw threads can be cut in a hole with the use of a:
   a) tap
   b) die
   c) tap drill
   d) body drill

3. Metal chips and heat are carried away from machine cutting tools by the use of:
   a) grease
   b) asbestos
   c) a chip guard
   d) cutting oil

4. Testing a product in industry is done to insure:
   a) greater profits
   b) work for all employees
   c) quality production
   d) testing a worker's skill

5. One reason for successful mass production in industry is:
   a) unions
   b) high wages
   c) large factory buildings
   d) standardization of parts

6. Square bar stock can be cut to cylindrical stock by the use of the:
   a) milling machine
   b) lathe
   c) grinder
   d) drill press

7. At all times when using a lathe it is necessary to:
   a) hold the work in a three jaw chuck
   b) wear goggles
   c) operate the automatic feed
   d) apply cutting oil

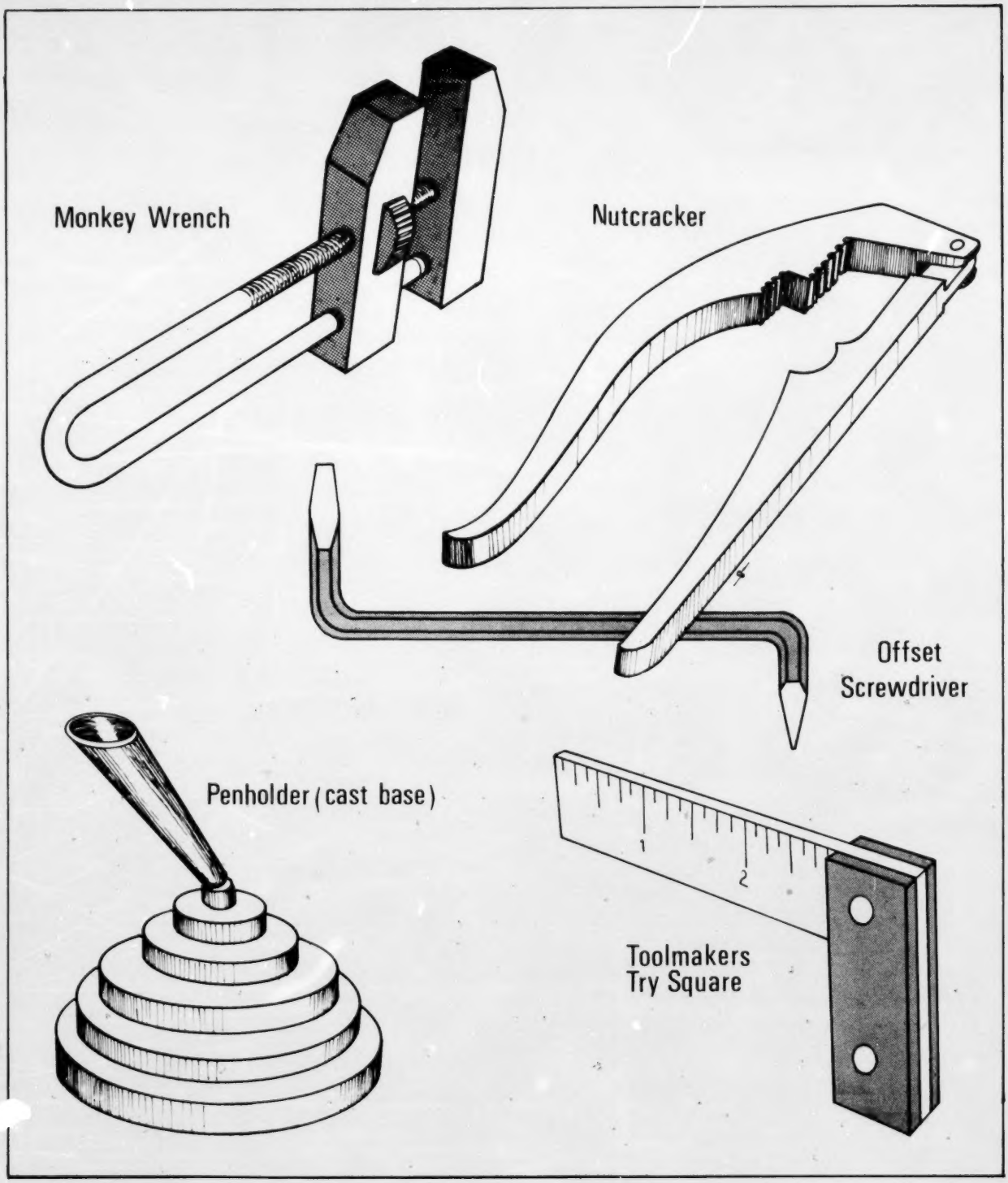
8. The most suitable material to select for the making of a center punch is:
   a) wrought iron
   b) mild steel
   c) drill rod
   d) hard brass

9. Countersinking a hole provides a recessed area so that it may receive the head of a:
   a) flat head machine screw
   b) round head machine screw
   c) fillister head machine screw
   d) machine bolt

10. To scribe a 1-1/2" circle, the divider must be set at:
    a) 1 1/2"
    b) 1"
    c) 3/4"
    d) 1/2"

11. The most accurate method of measuring the diameter of round stock being turned on the lathe is by the use of the:
    a) steel rule
    b) micrometer
    c) thickness gage
    d) outside caliper

12. The machine tool that is considered to be the most important in the metalworking industry is the:
    a) drill press
    b) milling machine
    c) grinder
    d) lathe


Monkey Wrench
Nutcracker
Offset
Screwdriver
Penholder (cast base)
Toolmakers
Try Square

SELECTED RELATED MATERIALS

Bench and Machine Metal

Books

Bench Work. Albany, N.Y.: Delmar, 1964.

Drill Press Work. Albany, N. Y.: Delmar, 1964.

Feirer, John L. and Lindbeck, John R. *Metalwork*. Peoria, Ill.: Chas. A. Bennett, 1970.

Johnson, Harold V. *Technical Metals*. Peoria, Ill.: Chas. A. Bennett, 1968.

Krar, S. F., Oswald, J. W. and St. Armand, J. E. *Technology of Machine Tools*. Toronto: McGraw-Hill, 1969.

Lathe Work. Albany, N.Y.: Delmar, 1964.

Ludwig, Oswald A. and McCarthy, Willard J. *Metalwork Technology and Practice*. Bloomington, Ill.: McKnight & McKnight, 1969.

McCarthy, Willard J. *Machine Tool Technology*. Bloomington, Ill.: McKnight & McKnight, 1968.

Smith, Robert E. *Bench Metalwork*. Bloomington, Ill.: McKnight & McKnight, 1961.

Walker, John R. *Modern Metalworking*. Homewood, Ill.: Goodheart-Willcox. 1965.

Walker, John R. *Machining Fundamentals*. Homewood, Ill.: Goodheart-Willcox, 1969.

Wall Charts

Decimal Equivalents and Tap Drill Sizes; How to Read a Micrometer; Tool Chart; Tools and Applications. L. S. Starret Co., Athol, Mass. 01331.

The Modern Lathe; Lathe Cutting Tools. Clausing Division, Atlas Press Co., 1915 North Pitcher St., Kalamazoo, Mich. 49001.

How to Become a Machinist; Engine Lathe; Decimal Equivalents; Tap Drill Sizes. South Bend Lathe, 400 West Sample St., South Bend, Ind. 46623.

Motion Pictures

Tool and Die Making (17 min.). Explains and demonstrates the importance of the machine industry that produces tools and dies. Bureau of Audio-Visual Instruction, 131 Livingston Street, Brooklyn, N. Y. 11201.

Precision Toolmaking and Machining (25 min.). Describes that phase of the metalworking industry where craftsmanship reaches its peak. Produced by the National Tool, Die, and Machining Association. Distributed by Modern Talking Picture Service, 2323 New Hyde Park Road, New Hyde Park, N. Y. 11040.

One Hoe for Kalabo (27 min.) Relates how power machines replace human muscle power, and illustrates the interchangeability of parts without which quantity production would be impossible. Produced by the National Machine

Tool Builders' Association. Distributed by Modern Talking Picture Service.

The Carmakers (27 min.). Indicates how the vital relationship between men and machines makes possible the mass production of automobiles in a modern industrial plant. Produced by Volkswagon. Distributed by Modern Talking Picture Service.

The Common Denominator (13 min.). Relates the history and use of hand tools down through the ages – from the Stone Age to the Missile Age. Produced by Proto Tool Company. Distributed by Modern Talking Picture Service.

The Tools and Rules for Precision Measuring (38 min.). Explains how precision tools control quality in mass production by showing the latest methods and equipment in practical use. L. Starrett Company, Athol, Mass. 01331.

Guides and Pamphlets

ABC's of Hand Tools. General Motors Corporation, Public Relations Staff, General Motors Building, Detroit, Mich. 48202.

File Filosophy. Nicholson File Company, 667 Waterman Ave., East Providence, R. I. 02941.

How to Read, Use, Care for a Micrometer. L. S. Starrett Co., Athol, Mass. 01331.

How to Run a Drill Press. South Bend Lathe, 400 West Sample St., South Bend, Ind. 46623.

Machine Tools – America's Muscles. National Tool Builders Association, 2139 Wisconsin Ave., Washington, D.C. 20007.

CAST METALS

Metal casting has played a significant role since the beginning of recorded history. For thousands of years, the process of pouring molten metal into molds has remained more of an art than a science. However, during the past few decades, in response to the ever-increasing demands of the industrial economy, the cast metals industry has made modifications that have been based on modern technology resulting in more efficient methods and greater production.

The cast metals industry reaches into all parts of the economy – the home, school, farm, and factory. Castings are required in 90% of all durable goods manufactured – either as end products or as component parts. Because castings are used directly or indirectly in practically all manufactured articles, the industrial arts student should be acquainted with this vital segment of the metalworking industry. The student should be aware, for example, that the automobile engine is cast directly from molten iron or aluminum, while the cloth woven on looms is dependent on cast metals because the looms on which the material is fabricated is designed with many metal parts that are produced by the casting method.

Foundry work in the intermediate or junior high school is a highly motivational activity with great appeal to the youngster, thus increasing the interest in the metalworking course. Preparing the sand, making the mold, and pouring the molten metal are intriguing and challenging operations to the student. The moment of retrieving the casting, once the metal has cooled, is an exciting one.

ADMINISTRATIVE TECHNIQUES IN THE FOUNDRY AREA

A small, functioning foundry unit adds an important dimension to the metalworking program. Equipment is relatively inexpensive and is readily available in the form of foundry kits. While a gas-air furnace that can melt aluminum is preferred, the ordinary gas furnace will provide sufficient heat to melt low-melting point alloys which can serve as the medium to demonstrate the fundamentals of foundry work. To illustrate a variation of the process, permanent molds, such as those that produce fishing sinkers or toy figures, can be used in addition to the sand mold.

Patterns should be of simple design, devoid of excess ornamentation. Pupils can be encouraged to construct their own patterns by cutting or carving soft wood, filing, sanding, and finishing the pattern with a coat of shellac. As an outside preparation assignment, students can develop their own stylized designs by drawing decorative motifs based on simple animal or plant forms.

Commercially produced patterns that have been specifically designed for use in the industrial arts shop can be purchased at low cost from companies that advertise in the industrial arts periodicals. Other sources for patterns are those items found in the home, such as trivets and souvenirs that might be suitable as patterns for use in the metalworking shop.

To expedite casting activities within the foundry area, it is advisable to select uncomplicated, one-piece patterns which will not only facilitate mold construction, but will also allow for the easy flow of molten metal.

A two or three-man team of students can work together in the foundry sharing their experiences and cooperating in the execution of the molding and casting operations. The use of tempered sand will also conserve shop time.

Another approach that can accelerate cast metals activities is the application of the full mold casting method which uses polystyrene for the pattern. The teacher can experiment with polystyrene (styrofoam) as a material for patternmaking since it has been used successfully in both industry and school shop foundries. Because polystyrene can be readily worked with a knife, constructing the pattern requires minimal effort and equipment.

In the full mold casting method, the polystyrene pattern does not have to be removed from the mold, but is burned out, thus eliminating the need for draft and making it possible to include undercuts in the design. The full mold method of casting reduces the number of operations that are necessary when compared with conventional sand casting, thus speeding up the casting process.

INTEGRATING FOUNDRY WITH OTHER AREAS IN THE SHOP

After a casting has been cooled and removed from the sand, the relationship between the foundry and the other areas in the metalworking shop becomes evident. The student is in a position to observe that bench metal operations are utilized to cut the sprue and riser; flash and other rough spots must be removed. In addition, machining may be required for acquiring a smooth finish, obtaining an accurate diameter, or cutting a thread with a tap for assembly purposes. Thus, the sequence of operations that transforms the rough casting into a finished product can be observed or practiced by the student in the shop.

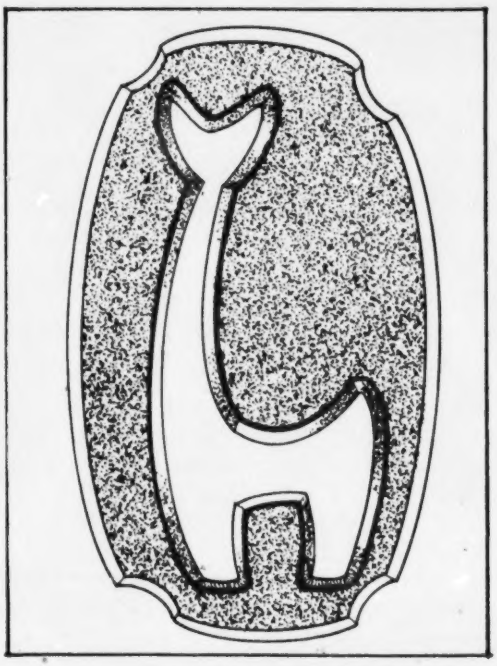
Further opportunities for integrating foundry with other areas exist by combining cast metal with wrought metal or sheet metal. For example, the casting of a metal plaque which can serve as the back support of the wrought metal tie rack (described in the wrought metal chapter) will indicate that different processes are interrelated. Similarly, the casting of decorative ornaments that can be added to the book ends (depicted in the sheet metal chapter) will demonstrate how the output from the foundry can relate to work being performed in another area of the metalworking shop.

SAFETY IN THE FOUNDRY AREA

The pouring of molten metal is necessarily a hazardous operation that requires strict adherence to safety regulations. Students must be protected by wearing safety apparel such as gloves, protective apron and a face shield; a fire blanket and fire extinguisher should be readily available. While the metal is cooling in the mold, a guard or sign must indicate that the metal is hot and should not be touched. The danger of having an excess amount of water deposited in the sand must be recognized.

UNIT PRODUCTION: CAST METALS

PRODUCT: Decorative Plaque (Stylized Form)



The suggested unit production activity for the foundry area involves the sand casting of an object that is derived from a simple one piece mold. An attractive wall plaque comprising a stylized design mounted on a backboard can serve as the medium for introducing metal casting to the class.

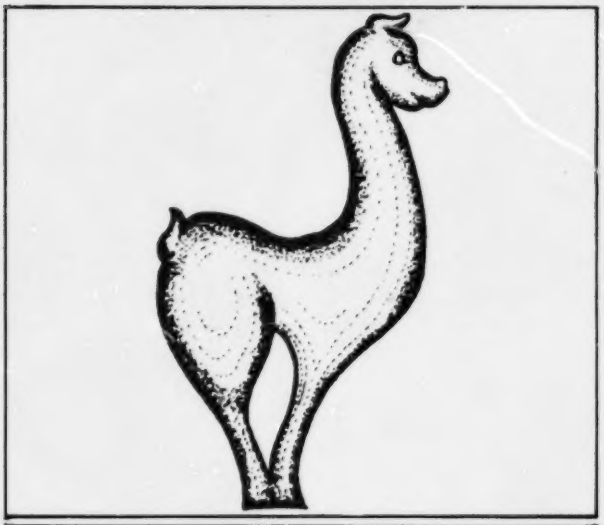
It is essential that the pupils understand the terminology that is associated with the foundry area. They should be informed of the purpose of the pattern and the elements that must be considered in its design and construction. The need for fillets and the use of the shrinkage rule must be explained.

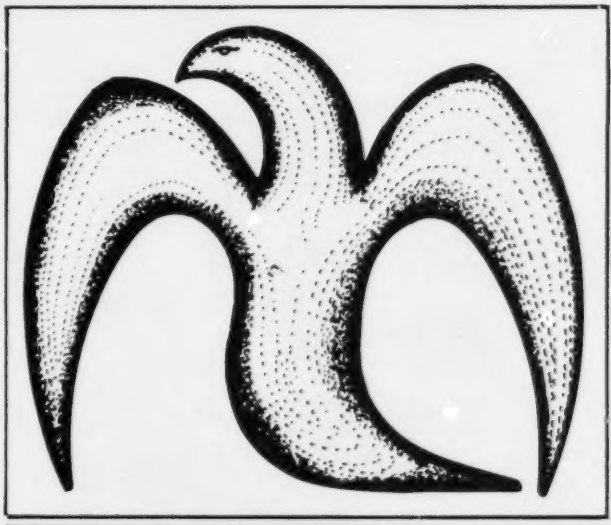
Packing the sand with the butt end of a rammer

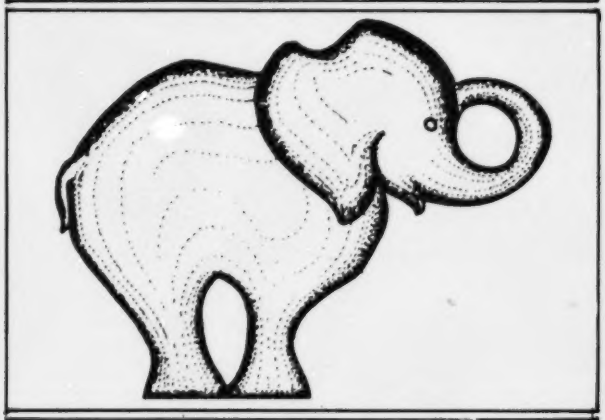
Opening the mold after cooling

Pouring the molten metal. Note — Student wears protective **gloves while holding handle of ladle**

DECORATIVE WALL PLAQUES: Alternate Design Ideas

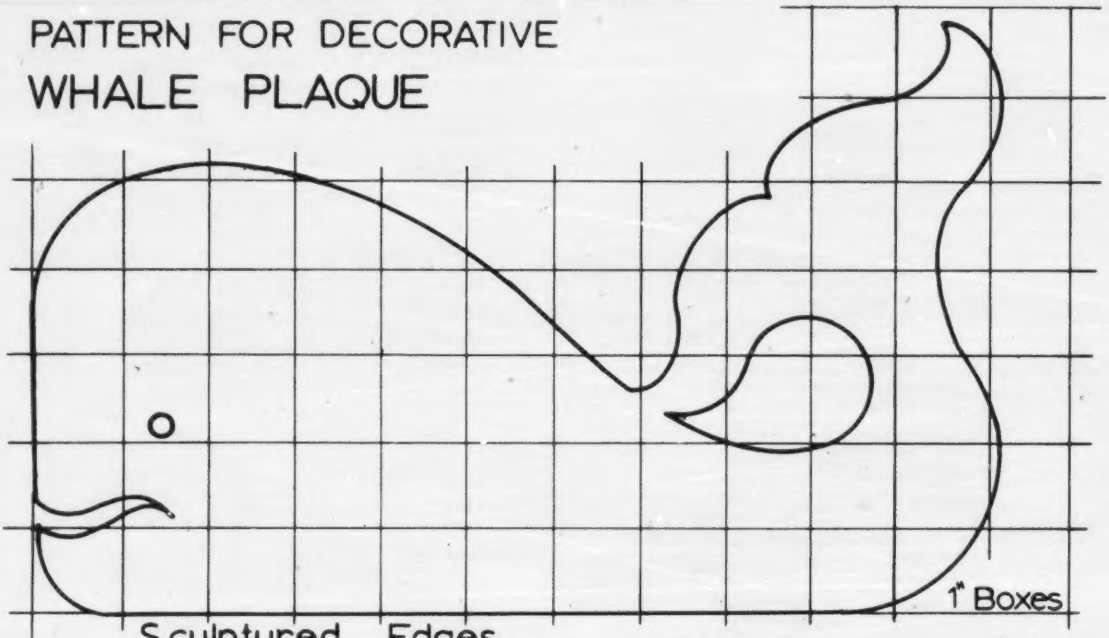




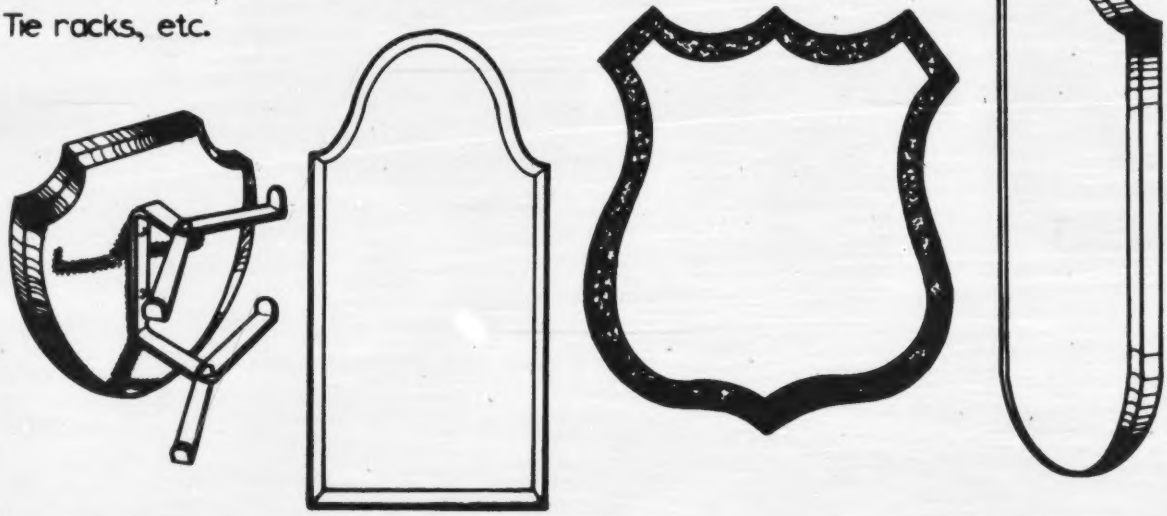


SIMPLE ONE PIECE PATTERN

PATTERN FOR DECORATIVE
WHALE PLAQUE



These plaques can be used for back supports.
Tie racks, etc.



OPERATION SHEET

DECORATIVE PLAQUE

Sequence	Operation Description	Tools and Equipment
1	Position pattern on molding board. Place drag on molding board (pins facing down on drag)	Molding board, pattern, drag
2	Sprinkle parting powder over pattern	Parting powder
3	Riddle sand over pattern covering it completely. Shovel sand into drag	Riddle, shovel, molding sand
4	Ram sand and overfill drag	Rammer
5	Level sand	Strike-off bar
6	Add bottom board and turn drag over.	Bottom board
7	Place cope over drag	Cope
8	Dust parting powder over drag surface. Locate and set sprue and riser pins	Parting powder, sprue pin, riser pin
9	Riddle sand over pattern. Fill flask.	Riddle, shovel, sand
10	Ram cope with peen end. Add excess sand. Ram with butt end. Strike off.	Rammer, shovel, strike-off bar
11	Vent cope. Remove sprue and riser pins. Form funnel-shaped opening at sprue hole.	Vent wire
12	Remove cope from drag	Draw pin
13	Moisten edges of mold next to pattern	Swab or bulb sponge
14	Rap draw pin lightly to loosen pattern. Lift pattern from mold.	Rapper
15	Cut gates	Gate cutter, slick and spoon
16	Blow off loose sand	Bellows
17	Replace cope on drag. Add weight on flask.	Cope, weights
18	Pour molten metal into sprue hole until it appears at the top of the riser hole.	Ladle, goggles
19	Cool mold and remove casting	
20	Remove excess material—sprue and riser	Hacksaw, vise

OPERATION SHEET (Continued)

21	Remove flash and rough spots	File, vise
22	Polish	Emery cloth, buffing wheel
23	Prepare backboard by drilling clearance holes for 10-32 F.H. machine screws. Countersink.	Center punch, hammer, drill press, countersink, twist drill (13/64 D.)
24	Drill holes in casting for 10 - 32 thread. Tap part way.	Drill, tap drill (#21)
25	Cut threads.	10 - 32 tap (bottoming), tap wrench, vise
26	Assemble casting to backboard	Screwdriver, 10 - 32 F.H. screws
27	Inspect	

Foundry equipment including flask, rammer, riddle and matchplate. Cast metal parts after removal from mold

DEMONSTRATION LESSON PLAN

Topic: Mold Making (sand)

Aim: To teach concepts and procedures for making a sand mold in the school shop and commercial foundries.

Preparation:

Sand	Riddle	Slick
Molding board	Rammer	Bellows
Bottom board	Shovel	Vent wire
Cope	Sprue pin	Parting compound
Drag	Riser pin	Strike-off bar
Pattern	Gate cutter	Bulb sponge

Visual Aids:
Instruction sheets, photographs of industrial foundry equipment.
Samples of cast parts, identification labels on panel holding equipment.

Motivation:
Show photograph of an attractive automobile.
What material is used for the engine? How is the engine block formed?

Procedure:
1. Temper sand. Add water sparingly. Stress safety concerning water content.
2. Place pattern and inverted drag on molding board (pins down).
3. Follow sequential operations in making mold.
4. Name molding tools as they are used and describe function.
5. Compare shop and industrial equipment and procedures. Mention the use of pneumatic tools, assembly line, match plates, other casting methods.

Summary:
Define tempering of sand.
Review important steps in mold making.
Describe function of various pieces of foundry equipment.
Stress safety in mold making.

Application:
Students participate in making a sand mold for unit production activity.

Assignment:
Identify each piece of foundry equipment that is depicted on the Foundry Equipment Identification Sheet. Present the completed test to the instructor before starting work in the cast metals area.

References:
Feirer, J.L. and Lindbeck, John R. I.A. Metalwork. Unit 35, "Metal Casting" pp. 162-170.
Ludwig, Oswald A. and McCarthy, Willard J. Metalwork Technology and Practice. Unit 47, "Molds and Molding" pp. 371-386.

RELATED LESSON PLAN

Topic: Alloys

Aim: To examine the role of alloys in the school shop and industry.

Preparation:

Samples of alloys and non-alloys in sheet and foil forms: Copper Brass Aluminum Zinc sheet (old dry cell) Coins Subway token Solder Air-Gas torch Asbestos pad Steel block Ball peen hammer

Motivation:

Show coins: half-dollar, dime. Explain why the older coins have been removed from circulation and replaced by new coins of the same denomination and size but with different ingredients.

Procedure:

1. Display a variety of metallic elements: copper, aluminum. Elicit definition of an element.
2. Produce an alloy by wrapping copper foil around zinc and melting the metals with an air-gas torch. SAFETY: USE AN ASBESTOS PAD.
3. Differentiate between an element and an alloy.
4. Discuss the use of alloys in the shop: brass, bronze, nickel silver, steels, solder, foundry metals. Describe properties.
5. Indicate the importance of alloys in industry: alloys used in cutting tools; high speed steel, tungsten carbide. Space Age applications -- resistance to heat and fatigue. Research in laboratories for new alloys-metallurgist.
6. Describe advantages and disadvantages of alloys.

Summary:

Define an element. Name some common metallic elements.
Define an alloy. Name some common alloys used in the shop and industry.
Review the advantages of alloys.

Applications:

Students use alloys in the shop: low-melting point alloy in foundry, solder in sheet metal.

Assignment:

Develop a chart listing five common alloys. Indicate composition, melting points, characteristics, and applications (or distribute printed assignment sheet, "Properties and Applications of Metals").

References:

Feirer, J.L. and Lindbeck, J.R. I.A. Metalwork. Unit 5, "Kinds of Metals" pp. 26-29.

Ludwig, Oswald, A. and McCarthy, Willard J. Metalwork Technology and Practice. Unit 20, "Steel Alloys" pp. 147-154; Unit 21, "Nonferrous Metals" pp. 155-163.

PROPERTIES AND APPLICATIONS OF METALS

METALS	Composition Chem. Symbol	Ferrous or Nonferrous	Melting Point	Magnetic or Nonmagnetic	Color	Surface Hardness Hard Med. Soft	Applications
ALUMINUM							
BRASS							
BRONZE							
COPPER							
LEAD							
NICKEL SILVER							
STEEL							
TIN (PLATE)							
ZINC (GALVANIZED IRON)							

MAKING A SAND MOLD

1

a) PLACE THE PATTERN ON MOLD BOARD.
b) TURN DRAG FACE DOWN, CENTER OVER PATTERN. PINS ON DRAG FACE DOWN

2

a) DUST PARTING POWDER OVER PATTERN.
b) POWDER PREVENTS SAND FROM STICKING.

3

a) RIDDLE SAND, COMPLETELY COVER PATTERN.
b) FILL DRAG WITH ADDITIONAL UNSCREENED SAND.

4

a) RAM SIDES TIGHTLY WITH PEEN END OF RAMMER
b) OVERFILL DRAG WITH SAND AND RAM WITH BUTT END.

5

STRIKE OFF TO LEVEL SAND.

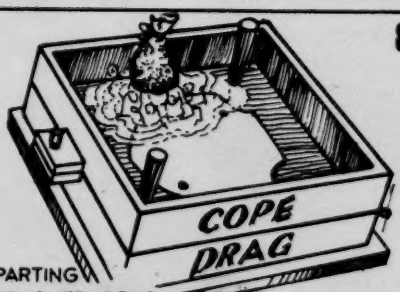
6

a) PLACE BOTTOM BOARD OVER SAND FILLED DRAG.
b) TURN DRAG OVER.

7

PLACE COPE PORTION OF FLASK ON DRAG.

8



a) DUST PARTING POWDER OVER DRAG SURFACE.
b) LOCATE AND SET SPRUE AND RISER PINS.

9

a) RIDDLE SAND OVER PATTERN.

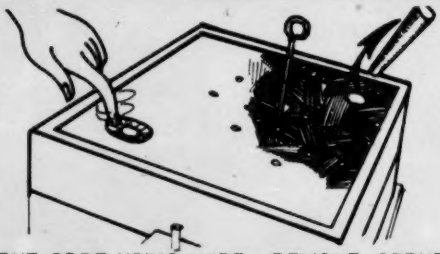
b) FILL FLASK COMPLETELY WITH UNSCREENED SAND.

10

a) RAM COPE WITH PEEN END. ADD EXCESS SAND. RAM WITH BUTT END. STRIKE OFF SURFACE.

b) SAND SHOULD NOT BE PACKED TOO TIGHTLY SO AS TO ALLOW FOR GASES TO ESCAPE.

11



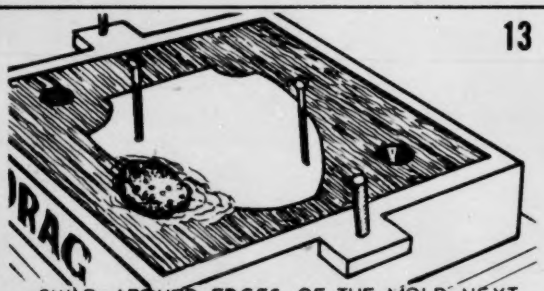
VENT COPE USING WIRE. REMOVE SPRUE AND RISER PINS. ROUND OFF TOP OF SPRUE HOLE INTO FUNNEL SHAPE.

12

a) LIFT OFF COPE AND PLACE ON SIDE.

b) INSERT DRAW PIN INTO THREADED HOLE OF PATTERN.

13

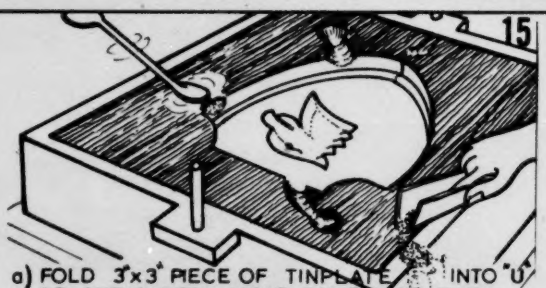


SWAB AROUND EDGES OF THE MOLD NEXT TO THE PATTERN. KEEP MOISTURE CONTENT LOW TO PREVENT STEAM BLOWS.

14

RAP DRAW PIN LIGHTLY TO LOOSEN THE PATTERN. LIFT PATTERN OUT OF MOLD.

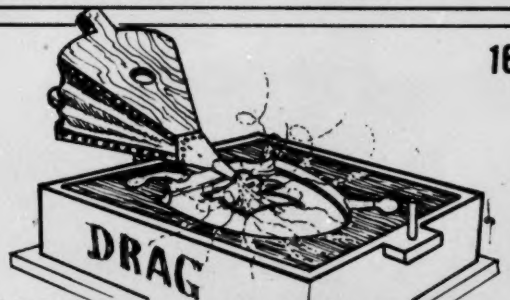
15



a) FOLD 3"x3" PIECE OF TINPLATE INTO U TO CUT GATES... MOLD CAVITY TO PINS.

b) CUT GATES. PATCH UP SMALL BREAKS IN THE MOLD USING THE SLICK AND SPOON.

16



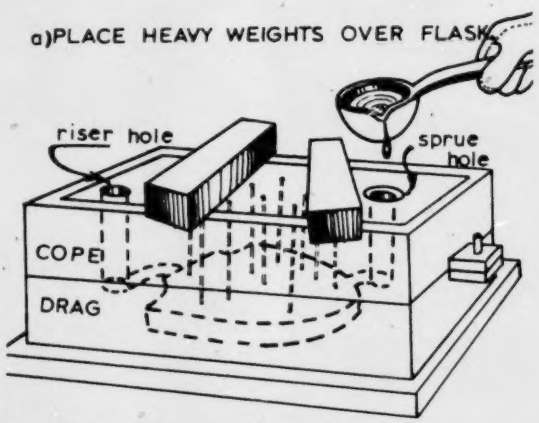
a) BLOW OFF ALL LOOSE SAND WITH BELLOWS.

b) INSPECT MOLD BEFORE CLOSING.

POURING THE SAND MOLD

1

a) PLACE HEAVY WEIGHTS OVER FLASK.



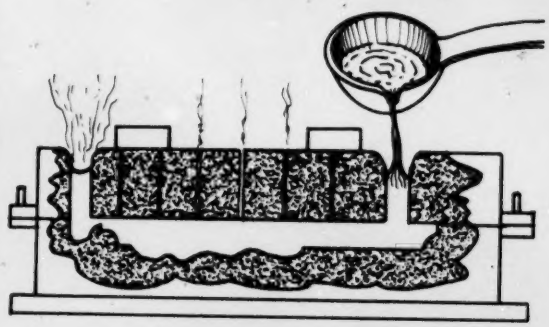
b) WEAR GLOVES TO HOLD LADLE WHEN POURING MOLTEN METAL.

c) WEAR GOGGLES TO PROTECT THE EYES.

2

a) POUR MOLTEN METAL INTO SPRUE HOLE.

b) POUR A STEADY STREAM UNTIL THE MOLTEN METAL SHOWS IN THE TOP OF THE RISER HOLE.



c) ALLOW METAL TO COOL.

3

a) REMOVE CASTING FROM THE SAND AFTER THE METAL HAS COOLED.

b) BRUSH SAND FROM THE METAL.

c) CHECK QUALITY OF CASTING.

4

a) CUT EXCESS MATERIAL (GATES, SPRUE, & RISER) WITH HACKSAW.

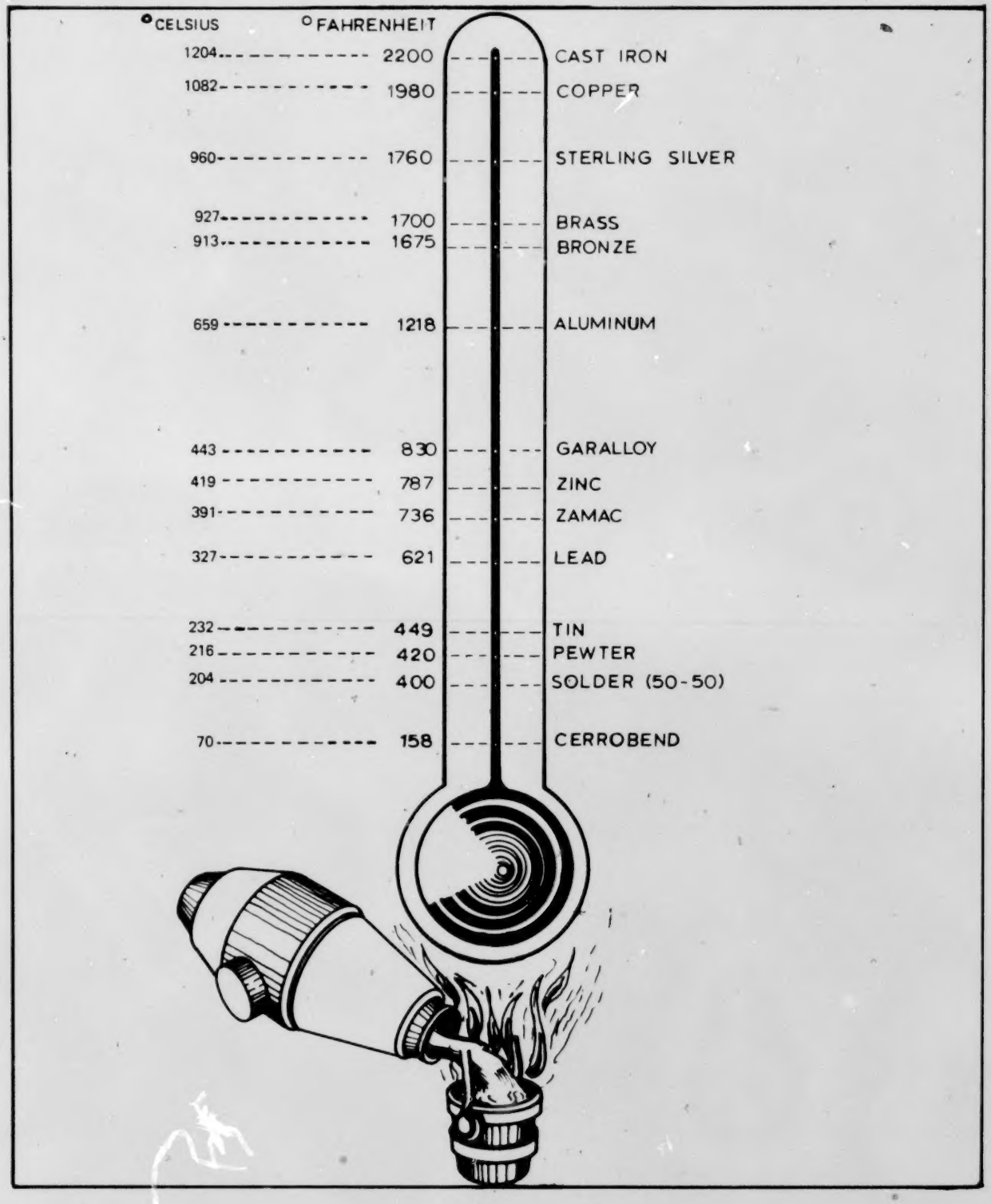
b) FILE ROUGH SPOTS CLEAN & SMOOTH.

c) MACHINE CASTING, IF NECESSARY.

d) CLEAN CASTING WITH EMERY CLOTH.

e) POLISH INTO COMPLETED PRODUCT.

MELTING POINTS OF METALS: Sample Related Information Sheet



MASS PRODUCTION: Cast Metals

The most practical procedure for introducing mass production concepts as they relate to cast metals is for the teacher to describe briefly some of the labor-saving techniques being applied in the foundry and to show a film depicting sand casting operations being performed in a large, modern manufacturing plant.

Automation is making inroads into the field of casting which is considered to be one of the most difficult metalworking processes to automate. Automation involves a foundry system in which mold and core sand are conveyed into precision molding, core setting, mold assembly, metal pouring, cooling, shakeout, and back through a sand-reclamation system to molding again. The system uses the carbon dioxide processes for hardening of molds and cores, and utilizes conveyor belts and walking beam conveyors with transfer mechanisms that are similar to those used with machine tools. In one foundry, for example, a normal 20-man operation required for the production of 120 molds per hour was accomplished with four men — a control operator at the console, and a monitor each for sand mixing, melting and shakeout. The shift to the automated process not only reduced manpower requirements, but also resulted in castings that were superior in qualities such as density and surface finish.

Automated foundry methods as they are applied in one of the world's most modern foundries are depicted in an excellent thirteen-minute motion picture entitled, *Tomorrow's Foundry Today*. This film is available for classroom use and can be borrowed free of charge from the General Motors Film Library, General Motors Building, Detroit, Michigan 48202.

OCCUPATIONAL INFORMATION: Cast Metal

FOUNDRY TECHNICIAN

TYPE OF EMPLOYMENT: The technician collects data, makes computations, performs laboratory tests, and writes reports. This employee uses drawing instruments, gages and scientific measuring equipment, and often supervises and maintains the machines located in plants and offices. The technician may test molding and core-making sand, make chemical analyses of metal, and operate machines that test the strength of castings. In this work the X-ray or magnetic apparatus may be used to inspect the internal structure of castings.

WHERE EMPLOYED: Technicians are employed in foundries where they can demonstrate their ability. They have acquired such job titles as general supervisor, plant superintendent, plant engineer, sales engineer, etc. Metallurgical technology graduates have advanced to positions as chief metallurgist, melting superintendent, and molding superintendent.

TRAINING: Upon graduation from high school, the student desiring to become a technician can enroll in a community college, two year technical institute, or junior college. After the student graduates from a two year school as a technician with an associate degree, it is possible, while gainfully employed, to continue his or her education during the evenings at a nearby college or university.

Machinist checks size of a bored hole on a casting using an inside micrometer

SUGGESTED QUESTIONS: Cast Metals

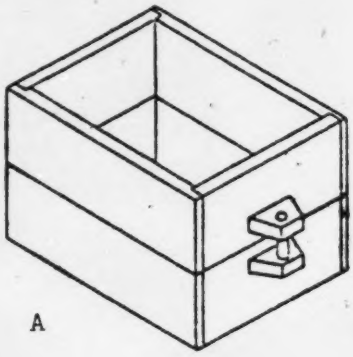
Complete the following questions by filling in each blank space with the correct answer.

1. Molten metal is carried and poured from a _____.
2. An instrument that measures the temperature of the molten metal is called a _____.
3. The holes made in a mold to allow for the escape of steam and gases are known as _____.
4. Patterns are made slightly larger than the size of the finished casting to allow for _____.
5. All loose sand from the sprue or mold is blown out by using _____.
6. When the correct amount of water has been mixed uniformly with molding sand, the sand is said to be properly _____.
7. The passageway in the mold, connecting the mold cavity with the sprue hole is known as the _____.
8. The place where molds are made and metal is poured is known as _____.
9. The tapered sides of a pattern that allow for the easy removal of the pattern from the mold is called _____.
10. After the metal is poured, do not remove the casting from the mold until the casting has _____.

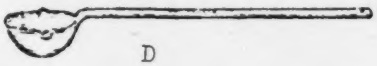
FOUNDRY EQUIPMENT IDENTIFICATION SHEET AND TEST

The following equipment is used in the foundry:

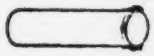
Bellows	Molding Board	Flask
Rammer	Slick and Spoon	Bulb Sponge
Protective Gloves	Ladle	Cope
Drag	Riddle	Sprue Cutter



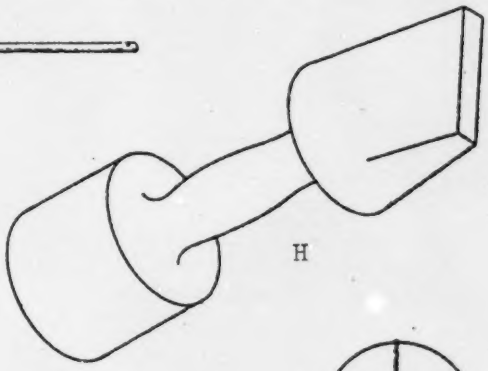
A



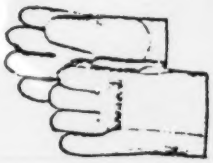
D



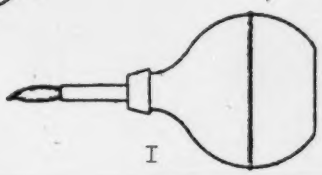
E



H



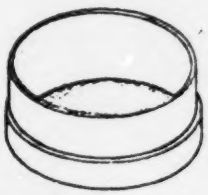
F



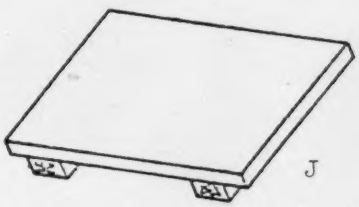
I

B

C



G



J

INSTRUCTIONS: Identify each of the objects above by filling in the correct name in the appropriate space.

A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

G. _____

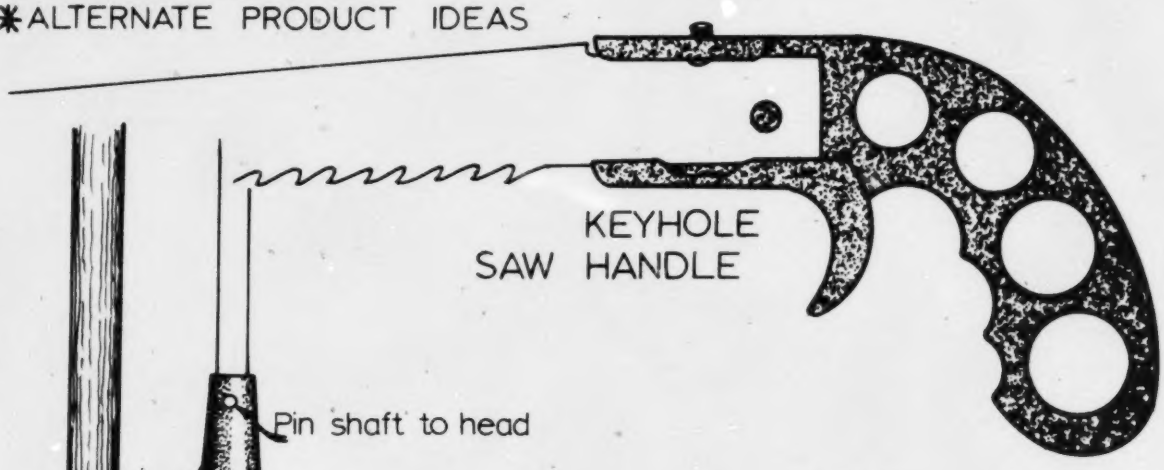
H. _____

I. _____

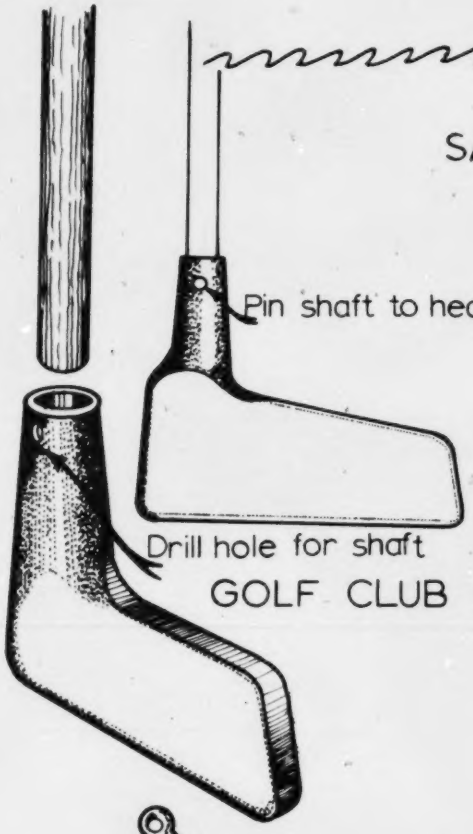
J. _____

CAST METALS

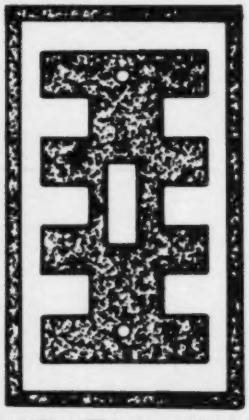
✱ALTERNATE PRODUCT IDEAS



KEYHOLE SAW HANDLE

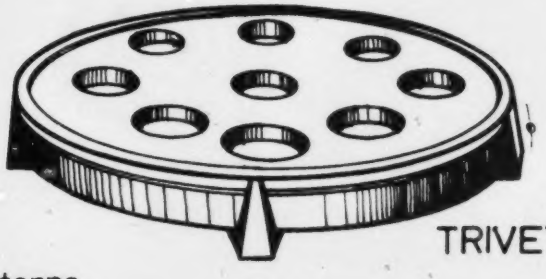


GOLF CLUB HEADS



ORNAMENTAL WALL SWITCH PLATE

FISHING SINKER



TRIVET

✱ Commercial products used as patterns.

SELECTED RELATED MATERIALS

Cast Metals

Books

American Foundrymen's Society. *Metalcasting Instructors Guide.* Des Plaines, Ill.: American Foundrymen's Society Training and Research Institute, 1967.

Ekey, D. C. and Winter, W. P. *Introduction to Foundry Technology.* New York: McGraw-Hill, 1958.

Flinn, R. A. *Fundamentals of Metal Casting.* Reading, Mass.: Addison-Wesley, 1963.

Miner, Harvey D. and Miller, John G. *Exploring Patternmaking and Foundry.* New York: Van Nostrand, 1959.

Slade, Edward. *Metals in the Modern World.* New York: Doubleday, 1968.

Smith, Robert E. *Patternmaking and Founding.* Bloomington, Ill.: McKnight & McKnight, 1954.

Magazines

Foundry. Penton Publishing Co., 1213 West 3rd St., Cleveland, Ohio 44113.

Iron Age. Chilton Co., Chestnut & 56th St., Philadelphia, Pa. 19139.

Modern Castings. American Foundrymen's Association, Des Plaines, Ill. 60016.

Precision Metal Molding. Industrial Publishing Co., 614 Superior Ave. West, Cleveland, Ohio 44113.

Brochures and Pamphlets

An Elementary Foundry Manual. McEnglevan Heat Treating & Manufacturing Co., P.O. Box 31, 700 Griggs St., Danville, Ill. 61832.

On the Subject of Casting. Avnet Machinery, 91 Commercial St., Plainview, N.Y. 11803.

From Mine to Ingot. Climax Molybdenum Company of Michigan, 1600 Huron Parkway, Ann Arbor, Mich. 48105.

New Dimensions in Steel Making. American Iron and Steel Institute, Teaching Aids Distribution Center, Bedford Hills, N.Y. 10507.

The Age of Steel. Inland Steel Co., 30 West Monroe St., Chicago, Ill. 60603.

Iron Ore Today. American Iron Ore Association, 600 Buckley Building, Cleveland, Ohio 44115.

A Trip Through Lone Star Steel. Lone Star Steel Co., West Mockingbird Lane, P. O. Box 1226, Dallas, Texas 75225.

Crucible Melting Handbook. Crucible Institute, P.O. Box 365, Jersey City, N. J. 07303.

Wall Charts

A Guide to Steel Making. Inland Steel Co., Public Relations Department, 30 West Monroe St., Chicago, Ill. 60603.

The Story of Steel. Educational Services, United States Steel Corporation, 600 Grant St., Pittsburgh, Pa. 15219.

Motion Pictures

Tomorrow's Foundry Today (13 Minutes). Describes one of the world's most modern foundries. General Motors Corp., Central Foundry Division, Public Relations Department, 37 Florence St., Saginaw, Mich. 48605.

Cast Metals and You (28 Minutes). The role of cast metals in daily living; training and growth opportunities in the metal casting industry; basic processes and typical industrial applications. American Foundrymen's Society Film Library, Golf and Wolf Roads, Des Plaines, Ill. 60016.

Die Casting: How Else Would You Make It? (35 Minutes). Describes the process of die casting. Rothacker, Inc., 241 West 17th Street, New York, N. Y. 10011.

Foundry Flexibility (29 Minutes). Depicts scenes in a highly mechanized malleable iron foundry. Link-Belt Co., Public Relations Department, Prudential Plaza, Chicago, Ill. 60601.

Centuries of Integrity (20 Minutes). Shows modern manufacturing of cast iron pipe and fittings. Modern Talking Picture Service, 2323 New Hyde Park Road, New Hyde Park, N. Y. 11040.

Research in Steel (26 Minutes). Inside the research laboratory of a large steel company. United States Steel Corp., New York Film Center, 71 Broadway, New York, N. Y. 10006.

Straight Line to Production (27 Minutes). A story of the casting processes used for casting iron. Gray & Ductile Iron Founders' Society, 930 National City-E. 6th Building, Cleveland, Ohio 44114.

Occupational Information

Your Future in the Metal Castings Industry. American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill. 60016.

The Foundry Is a Good Place to Work. American Foundrymen's Society.

Engineering and Technical Career Opportunities in the Cast Metals Industry. The Foundry Educational Foundation, 1138 Terminal Tower, Cleveland, Ohio 44113.

A Career in Metallurgy Will Extend Your Reach. The International Nickel Co., 67 Wall St., New York, N. Y. 10005.

GUIDANCE

One of the most valuable contributions that industrial arts education can make in the intermediate and junior high school curriculum is to provide an environment which will promote effective guidance for those students who are enrolled in the program. The exploratory nature of industrial arts at the intermediate and junior high school level not only serves to introduce industrial technology, but also helps to fulfill the guidance objective by presenting career possibilities to the students. In the metalworking shop, the students are introduced to the world of work as it relates to the metalworking industry. They become aware, for the first time, of the requirements responsibilities, and rewards of specific metalworking occupations.

GUIDANCE FUNCTION IN THE METALWORKING SHOP

The teacher of metalworking can give positive direction that is relevant to the needs of each student. The instructor is in a most advantageous position to provide practical assistance in the form of advice concerning possible educational and vocational goals. Because the instructor can observe the student at work, judgments can be made relating to pupil capabilities and interests.

The metalworking shop is, in a sense, a guidance laboratory where the individual is involved, not only in work experiences, but also in interacting with other students in surroundings that are less rigid than in the traditional classroom. The shop furnishes an environment which promotes a much closer relationship between the teacher and student than is usually found in the academic classroom. The informal atmosphere of the metalworking shop affords an excellent opportunity for communicating and receiving feedback relating to individual traits. Through close personal contact and observation, the metalworking teacher can ascertain interests, ambitions, attitudes, and capabilities of each student. By noting the work habits and performance of members of the class, the teacher is in a unique situation where assistance can be given the pupils in self-development, in revealing and evaluating abilities and interests, and in acquainting them with those educational and occupational opportunities that lie ahead.

CHOICE OF A HIGH SCHOOL

Students in the intermediate and junior high school will be confronted with the serious problem of making the choice of a high school. It is not too soon to apprise the students of their responsibility to think of their occupational goals and to consider the education that will be required to attain them. The students should strive to acquire some general, overall perspective of career possibilities not only in the metalworking shop, but also in the other industrial arts areas, in order to make a rational decision concerning the choice of a high school. This selection should be based on their interests, potential for success, and the short-and long-range opportunities that exist in the field that is their choice.

When it can be determined that a student possesses specific capabilities and interests which will satisfy the requirements of a particular occupational field, it might be worthwhile for the pupil to investigate and to apply for admission to a specialized high school. If there is inadequate evidence pointing in any academic or vocational direction, the student can progress to the comprehensive high school where it may

Performing hand and machine tool operations reveals student skills and interests

be possible to discover some preferred area of concentration. The student can then choose the appropriate course for the final two years which will permit a successful pursuit of his or her educational and occupational objectives.

The importance of earning a high school diploma and obtaining as much education as possible beyond secondary school must be stressed. Students should be aware that the severest effects of increased automation are being felt by those in the unskilled job categories, while applicants for skilled occupations are being compelled to meet higher standards for employment.

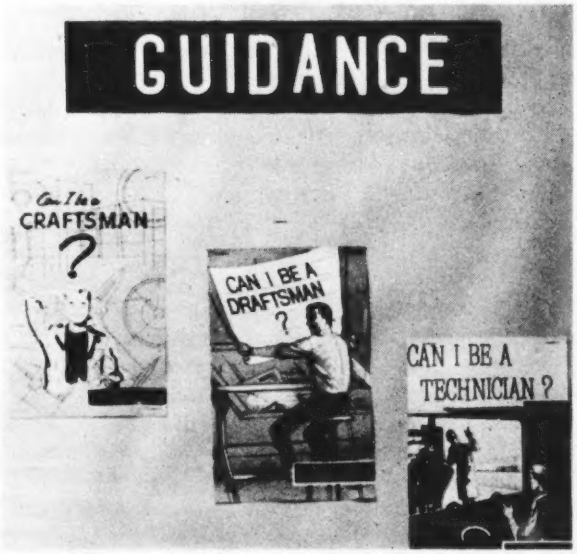
INDIVIDUAL GUIDANCE

Guidance is a motivating factor which can spur pupil interest in the metalworking program. At the beginning of the term, the class should be informed that the purpose of attending the metalworking shop is not only to learn how to use tools and machines, but also to accumulate information concerning personal characteristics. Discovering a person's likes and dislikes, talents and lack of abilities provides vital clues which can serve as a basis for making preliminary decisions affecting future activities at school and at work.

The importance of the guidance function in the metalworking shop can be more readily understood and appreciated by the student if the teacher demonstrates sincere concern for the future success of each pupil. It is essential that the teacher gain the confidence of the student by showing a genuine interest in the student's welfare. The more information that the teacher can obtain concerning the abilities of each member of the class, the better equipped the instructor will be to give practical advice. By utilizing one or more of the following approaches, the instructor can obtain invaluable data which will add immeasurably to evaluation of the student's background and qualifications.

INDIVIDUAL GUIDANCE TECHNIQUES

1. Observe the student at work. Note the level of skills, for example, in manual dexterity, numerical, spatial, creative, and problem solving abilities. Record pertinent data on the Proficiency-Interest Inventory Card.
2. Test the student by means of performance and written examinations to determine the degree of comprehension and relative standing in class.



3. Ask questions, in an informal manner during the term, as to the present status and future intentions of the student. Give evidence of personal interest in the pupil. Note student preferences on back of Proficiency-Interest Inventory Card.

4. Consult with guidance counselor, department chairmen, and other school personnel to obtain additional information.

5. Confer with parents on Open School Night, or on their class visits during the school term. Listen to the parents' point of view concerning their hopes and aspirations for their child.

6. Examine the cumulative record to determine past performance in industrial arts classes and other school subjects. Note weak and strong areas, health record, mathematics, and reading scores.

PROFICIENCY-INTEREST INVENTORY CARD

The Proficiency-Interest Inventory Card facilitates the recording of pertinent data concerning student interests and skills. The information contained on the 3 x 5 index card adds to the teacher's knowledge of each individual and can be used in conjunction with other information that is recorded on the progress charts and in the teacher's grade book. The card can be conveniently stored in the teacher's permanent file for immediate or future reference, and can be helpful during conferences with parents, guidance counselors, and school administrators.

It is suggested that the printed cards be distributed to the class at the beginning of the term, at which time the purpose for acquiring information as stated on the Proficiency-Interest Inventory Card should be explained. The students should be instructed to write their name, class and term on the front of the card and to indicate their preferences on the back. Guidance factor ratings would be added by the teacher during the term. Not only does the card serve for recording information, it also indicates the teacher's desire to help the student to achieve success upon graduation from the intermediate and junior high schools.

PROFICIENCY-INTEREST INVENTORY CARD

Last Name _____ First Name _____ Shop Class _____

Shop _____ Term _____ Official Class _____

Rating Symbols: Above Average + Average | Below Average –

Guidance Factors	
Manipulative Skills *(Tool/Machine)*	
Communication Skills *(written/oral)*	
Mathematics Skills *(problem solving)*	
Design Skills *(creative/aesthetic)*	
	Midterm Grade
Midterm Exam _____ Final Exam _____	**Final Grade**

IA PROFICIENCY-INTEREST INVENTORY CARD

Side A — (Front)

Last Name _____ First Name _____

Interests (Hobbies)

1. _____
2. _____
3. _____

Job Preference (Careers)

1. _____
2. _____
3. _____

Other Industrial Arts Shops Attended

1. _____
2. _____
3. _____
4. _____

Teacher Comments

Side B — (Back)

GROUP GUIDANCE

As the metalworking shop classes progress, students will participate in operations actually performed in industry and, in a sense, they will acquire firsthand knowledge of the kind of work that takes place in the metalworking field. In addition to exposure to tool and machine operations, related information lessons covering the following broad areas can include topics that are closely allied to guidance:

1. Types of jobs in the metalworking industry.
2. Job opportunities in related metalworking fields.
3. The role of trade and industrial unions.
4. Trends in employment — automation, numerical control.
5. Teaching metalworking and other industrial arts subjects.

GROUP GUIDANCE TECHNIQUES

Other guidance activities which will acquaint students with employment possibilities in the broad field of metalworking are:

1. Visit the neighborhood metalworking establishments: sheet metal, machine shop, foundry, manufacturing plant.
2. Invite the guidance counselor to discuss opportunities for further education and employment.
3. Show a motion picture depicting workers on the job in the steel mill, foundry, assembly plant, etc.
4. Show guidance materials in shop and school display cabinets.
5. Use shop bulletin board to post Help Wanted advertisements seeking workers in various metalworking jobs.
6. Assign guidance research reports to students who will investigate duties and educational requirements for selected job categories.
7. Inspect exhibits at industrial shows depicting the products and processes of the metalworking industry. Machine tool, production engineering design and other industrial expositions are held periodically at the New York Coliseum under the sponsorship of professional engineering societies, manufacturing companies or trade organizations. Visits to these shows require the supervision of the teacher or other adult.
8. Organize an occupational information file in the shop planning center, containing up-to-date research reports relating to metalworking and related fields.

OCCUPATIONAL INFORMATION REPORTS

Each class attending the metalworking shop can contribute to the development of an occupational information file that would be located in the shop planning center. An outside preparation report devoted to a specific metalworking occupation can be a practical application of a research exercise. Each student selects one metalworking occupation from a list of job titles, and seeks out the required information. The class can be apprised of the sources of information, such as the school or neighborhood library, labor unions and trade associations. Outstanding reports can be duplicated and distributed to the class with copies kept on file for future reference.

JOB TITLES IN METALWORKING AND RELATED FIELDS

- Annealer
- Assembler
- Automobile Mechanic
- Aviation Mechanic
- Bench Mechanic
- Blacksmith
- Boilermaker
- Case Hardener
- Coremaker
- Diemaker
- Diesinker
- Drill Press Operator
- Electroplater
- Foundry Molder
- Gauge Maker
- Grinding Machine Operator
- Heat Treater
- Inspector
- Instrument Maker
- Jeweler
- Jig and Fixture Builder
- Lathe Operator
- Layout Person
- Machine Draftsperson
- Machine Operator
- Machine Set-Up Person
- Machinist
- Maintenance Person
- Manufacturing Engineer
- Mechanic
- Mechanical Engineer
- Metallurgist
- Metal Spinner
- Milling Machine Operator
- Millwright
- Modelmaker
- Ornamental Ironmaker
- Patternmaker
- Planer Operator
- Plumber
- Polisher
- Punch Press Operator
- Riveter
- Sheet Metal Worker
- Silversmith
- Solderer
- Structural Ironworker
- Technician
- Tool and Die Maker
- Welder

SAMPLE RESEARCH REPORT (OUTSIDE PREPARATION) OCCUPATIONAL INFORMATION

METALWORKING OCCUPATIONS	
JOB TITLE	
JOB DESCRIPTION	
SKILLS REQUIRED	
EDUCATION REQUIRED	
SAFETY HAZARDS	
WAGES OR SALARY	
SCHOOL OR TRAINING CENTERS	
ADVANCEMENT OPPORTUNITIES	
SOURCES OF INFORMATION	
GEOGRAPHICAL AREAS OF EMPLOYMENT	

This Research Report is submitted by

Name _____ Date _____

Shop Class _____ Official Class _____

CLASSIFICATION OF WORKERS

Unskilled Workers

These employees usually do not require special training. Their jobs frequently involve handling, wrapping or mixing materials. The long run decline in employment of unskilled workers has occurred largely because mechanized equipment has replaced manual labor. In an increasing number of plants, integrated systems of processing and materials handling equipment are being installed. Unskilled workers are usually the first to lose their jobs during a business recession and have the highest unemployment rate of all the major occupational groups.

Semi-Skilled Workers

Large numbers of semi-skilled workers act as helpers or assistants to skilled workers. Many are employed as assemblers and inspectors in manufacturing plants. In general, operators work with their hands using a variety of hand tools such as screwdrivers, pliers, files, soldering irons, measuring devices and cutting tools. In some cases, these workers also make elementary adjustments and do minor maintenance on the machines they use. The production machines that are operated by the semiskilled workers are those of a repetitive nature.

Skilled Workers

Skilled workers must have a thorough knowledge of the processes involved in their work, and therefore need considerable training to qualify for their jobs. A large proportion of skilled workers in the metalworking field learn their trade through informal on-the-job training. Others learn through an apprenticeship or other formal training program. Individuals also acquire the requisite skills and knowledge by attending vocational, trade, or technical schools.

These employees are responsible for constructing models, tools, dies, machines, and equipment without which industrial processes could not be carried out by semi-skilled or unskilled workers. Skilled workers repair the equipment that is used in industry and the mechanical devices used by the consumer. They must exercise considerable independent judgment in setting up and operating complex metalworking machines.

Technicians

The technician plays a vital role by working directly with scientists, engineers, and other professionals in every field of science and technology. The duties of the technician vary greatly depending upon his field of specialization. In general, the scientist or engineer does the theoretical work while the technician translates theory into action.

Professional Worker

Technicians trained in metalworking techniques help design new production methods (automation), new materials, machinery and control systems to make industry more productive. Technicians also assist in the development and production of new miracle metals and metal alloys for use in such fields as construction, manufacturing, and transportation.

Included under this occupational classification are the industrial engineer, mechanical engineer, metallurgist product designer and other categories which generally require graduation from a degree-granting college or university.

Welder at work wearing appropriate safety clothing for his personal protection

EDUCATIONAL OPPORTUNITIES

It is appropriate for the metalworking teacher to outline the avenues of education open to those class members who might desire to pursue a career in some phase of metalworking or its allied fields. For students interested in possible employment, it is not too early to ascertain the type of education needed to enter and be successful in the metalworking industry.

All students in the metalworking shop should be acquainted with available educational opportunities. They should discuss these possibilities with their parents at home, and with their advisers in school. The teacher in the metalworking shop should also be in close communication with guidance personnel, furnishing them with pertinent information concerning individual students who desire further education to qualify for positions in the metalworking industry. By the same token, it is the responsibility of the guidance counselor to cooperate with the metalworking teacher by reporting the latest information concerning employment trends, education programs, and entrance requirements that must be met to qualify for those programs that apply to the metalworking field.

Academic High School

Further exploration into the metalworking industry is afforded in the industrial arts metalworking courses that are offered in the academic high school. It is possible for the non-college bound student to learn a cluster of basic tool and machine skills which will be useful for entry into beginning jobs in metalworking companies. For the college bound student, exposure to industrial arts metalworking at the high school level will be an excellent preparation prior to his enrollment in the college in such professional programs as engineering and metallurgy.

Vocational High Schools

Selected vocational high schools are equipped to prepare students for a trade in the metalworking and allied fields. These occupational areas include sheet metal, foundry, jewelry making, machine shop, automotive machine work, airplane mechanics, and automobile mechanics.

Post High School Study

Qualified graduates of the New York City academic and vocational high schools are eligible to enroll in special, intensive one year vocational courses which prepare them for entry into skilled jobs in such areas as automobile mechanics, equipment repair, and machine shop. These courses concentrate on shop or laboratory training; there are no academic classes.

Technical Institute

The curriculum of the technical institute is organized to include intensive courses that stress almost entirely the practical phase of what the technicians will be required to know in order to perform their duties. Courses in scientific theory and mathematics are held to a minimum.

Junior and Community College

These institutions offer programs similar to the technical institute, but place greater emphasis on theory accompanied by a variety of liberal arts courses. In many cases, following the completion of the first two years of the program, it is possible for the student to transfer from the junior college to the senior college where subsequent courses will lead to the granting of a degree.

In New York City, provision has been made to accept qualified high school graduates to train as industrial arts interns by their attending community college and serving an internship in an industrial arts shop, including the metalworking shop.

Senior College and University

Students aspiring to pursue a career in mechanical or industrial engineering or metallurgy can enroll in the four year college or university. They can follow a program which will eventually grant them the professional status to qualify for entrance into the metalworking or allied industries.

SELECTED RELATED MATERIALS

Guidance

Twenty-Five Technical Careers You Can Learn in Two Years or Less. United States Department of Health, Education and Welfare, Washington, D. C. 20202.

Directory of the Public High Schools. Board of Education, Bureau of Educational and Vocational Guidance, 110 Livingston St., Brooklyn, N. Y. 11201.

Should You Be an Engineer? New York Life Insurance Co., Career Information Service, Box 51, Madison Square Station, New York, N. Y. 10010.

Can I Be a Technician? General Motors, Corporation, Public Relations Staff, General Motors Building, Detroit, Mich. 48202.

Technical Education News (published four times during the school year). McGraw-Hill Book Co., 330 West 42nd St., New York, N.Y. 10036.

The Engineering Technician. American Society for Engineering Education, 2100 Pennsylvania Ave., N. W., Washington, D.C. 20037.

Can I Be a Craftsman? General Motors Corporation.

Industrial Bulletin (published monthly). New York State Department of Labor, State Campus, Albany, N.Y. 12226.

TEACHING AIDS and MATERIALS

Effective instruction in the metalworking shop is dependent on the use of appropriate teaching aids. Verbal descriptions of operations and processes must be accompanied by visual materials so as to enable the student to understand concepts upon which metalworking technology is based. A variety of teaching aids that are described in this chapter are readily available, and their application will clarify and enhance the demonstrations and related information lessons, particularly for those students who have language difficulties or who are unable to comprehend the more abstract principles relating to metalworking.

CHALKBOARD

The chalkboard represents the most convenient visual aid in the metalworking shop. It can be used not only as a teaching aid, but also as a motivating device that will stimulate student interest in the lesson. Pupils can participate in the development of the lesson by writing and sketching on the chalkboard.

In order to be efficient, chalkboard technique requires that the written work be displayed in a neat, orderly, and sequential fashion. Technical terms discussed during the lesson should be spelled out and written on the board. When a relatively complex drawing is required, it should be placed on the chalkboard in advance, prior to the meeting of the class, rather than during the time that the class is in session.

TEXTBOOKS

Textbooks are a basic instructional aid, and their use by all students in the metalworking shop should be encouraged. Books serve as another educational tool to describe processes, machines, and materials relating to the metalworking industry. Individual needs are met by their use, allowing the slower learner to review and digest previous classroom work and to concentrate on those areas of knowledge that require additional time for study. For the more advanced student, textbooks contain supplementary material which may not be covered in the basic metalworking course, but which could be absorbed and provide a challenge, thus adding to the attractiveness of the program. Textbooks are also invaluable for assigning homework topics, practicing reading skills, and learning new technical terms.

Because the industrial arts teacher is responsible for the choice of suitable textbooks in the metalworking shop, their purchase and use should be based on a professional approach: direct examination of samples provided by the publishers, consultation with other industrial arts teachers and supervisors, exchange of views at industrial arts meetings and conventions, and reading reviews in the professional journals and newsletters of the national, state, and city industrial arts organizations.

When the teacher reviews a new metalworking book, it should be evaluated from the standpoint of its suitability as a reference source in the shop library or as a textbook for shop use. Selection of the textbook will depend on whether it satisfies student reading standards, relates closely to course content, contains illustrations and photographs, and offers possibilities for individual and class assignments.

NEWSPAPERS

The news media often contain news stories and feature articles that pertain to some facet of the metalworking industry. The financial section of the daily

newspaper will include a newsworthy item – reporting on a strike in a steel mill; the discovery of new natural resources such as coal, iron, or copper ore; the recycling of metal for the purpose of conservation, or the total annual tonnage of steel in this country as compared with other nations of the world.

Whenever an appropriate news item does appear, its social or economic relationship to the metalworking industry should be introduced in the lesson. When news information can be tied in with instruction in metalworking, it gives the lesson a sense of immediacy, and heightens the degree of motivation and meaningfulness. The teacher should, therefore, peruse the newspapers for pertinent articles that would update his presentations. These articles could then be collected in a folder to become resource materials for future lessons, and for students who might be assigned a research project requiring up-to-date data. The materials enclosed in the folder would contain information unavailable in textbooks.

Encouraging students to read newspapers and search for newspaper articles relating to metalworking developments would be beneficial, particularly if newspaper stories and photographs were brought to and discussed in class. Credit could be awarded to those pupils contributing materials for display on the shop bulletin board, or embellishing the shop notebook with relevant newspaper items.

Another use of the newspaper lies in the advertisements depicting metal products. These could be pasted in the shop notebook, providing the pupil with some perspective of the great range of products manufactured from metal. In addition, a student would be given some indication of the prices of these products.

MAGAZINES

Magazines are excellent sources for feature articles, photographs, and diagrams illustrating the advances being made in the metalworking industry. The periodicals range from those directed to engineers and technicians, *Iron Age* and *Machinery*, to those geared to the devotees of the home workshop, *Popular Science*, *Popular Mechanics*, and *Mechanix Illustrated*. Two professional journals dedicated to various aspects of industrial arts education, *Industrial Arts and Vocational Education* and *School Shop*, often include articles that describe shop activities involving the use of metals and metalworking equipment.

Magazines devoted to the metalworking trades supply the teacher with photographs of machinery used in industry. These may be shown during a lesson involving the use of shop equipment, allowing the teacher to compare shop tools and machines with those used in industry. In addition, trade magazines include the names of advertisers who are generally cooperative in forwarding samples of materials, booklets, and catalogs to educational institutions. The magazines, many with attractive covers, should be prominently displayed in the metalworking shop and made available for student use.

Relevant information, useful as data for shop reports, research assignments, and product development and construction, should be extracted from the magazines and deposited in a folder, or listed in a card file for future reference. The collection of magazines and periodical materials may be enlarged to serve as an important adjunct in the shop planning center.

INDUSTRIAL LITERATURE

Industrial literature, in the form of brochures and booklets, is a rich and inexpensive source for up-to-date information regarding metals, metal fabrication, and metalworking equipment. All types of printed matter, replete with photographs, diagrams, and descriptions of processes, are available to industrial arts teachers. These publications not only keep the metalworking instructor informed of the latest developments within the metalworking field, but can also suggest production activities or describe materials and machines that might be adopted for shop use.

Many large companies associated with metals and metalworking equipment publish and distribute to their stockholders annual financial reports that have an attractive layout and informative content. These reports containing illustrations, tables, and charts provide an overall perspective of the economic factors that affect industrial establishments. They can be used to indicate whether or not the companies have been successful during the year for they include a review of the year and a financial summary and balance sheet. A letter to the headquarters of a large corporation requesting annual reports in classroom quantities will usually be answered with a satisfactory response.

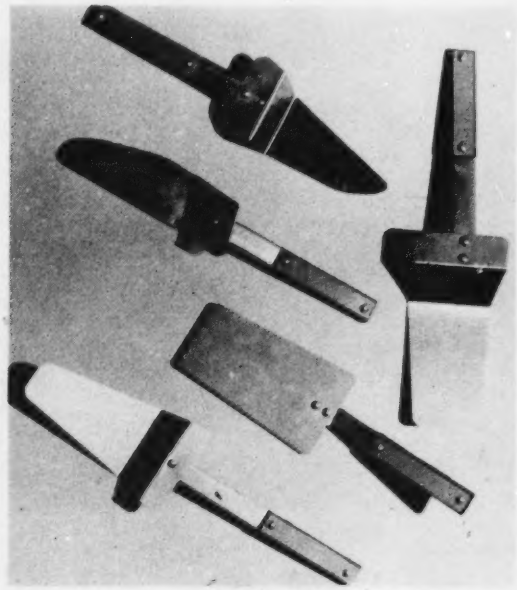
The pamphlets, brochures, and catalogs received in the metalworking shop can be added to the shop library collection and used to good advantage. A lesson on ordering tools from a catalog will prove bene-

ficial, or homework topics that are based on the library collection can be assigned to individual students or the entire class. New industrial literature is constantly being published and announced in the technical magazines and professional journals. Suitable printed materials should be obtained.

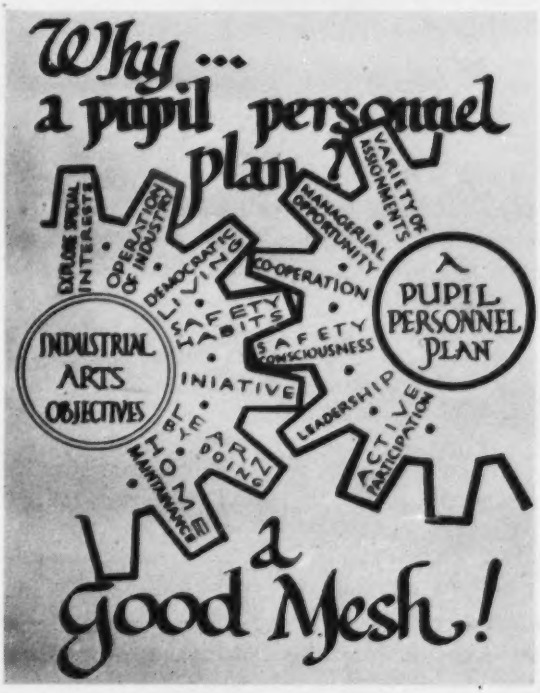
MODELS

Visual aids, in the form of three-dimensional models, facilitate the learning process by translating abstract ideas into more concrete terms. For example, an enlarged model of a tool bit or twist drill makes it easier for the instructor to define the cutting angle, describe the principle of the wedge, and explain the purpose of clearance. Similarly, a model that contains a cutaway section to illustrate internal structure helps clarify the verbal presentation of a process or operation. Thus, a model of a blast furnace which includes a half-section will simplify the teaching of nomenclature and make it easier for the student to understand the function of various parts.

The construction of models for use as visual aids can be an on-going group project within the metalworking shop. Planning and construction can be undertaken by a committee of students, particularly the more advanced pupils who would be contributing to the betterment of the shop, and who would be credited with a grade under the shop improvement category.



Charts and posters in the shop, not only decorate the room, but are also valuable teaching aids



POSTERS AND CHARTS

Wall posters and charts not only decorate the metalworking shop, but also furnish information to the viewer, and therefore, represent another important teaching aid. Safety posters, in particular, remind the class of safety regulations that must be followed. Just as manufacturing plants stress safety by publicizing safe procedures through the medium of the safety poster, so too can the school metalworking shop emulate an industrial practice by displaying posters that remind students to avoid hazards relating to tool and machine use and materials handling.

Students should be encouraged to design posters based on metalworking themes or shop safety rules. Attractive student-made posters can be tacked on the shop bulletin board or can accompany the industrial arts students-constructed products that are exhibited in the showcases situated in the school corridors. Motivating students to design shop posters as an outside assignment would not only involve them in the learning inherent in depicting the theme, but displaying the pictorial work would give recognition of their effort and artistic talents, in addition to publicizing the activities of the metalworking shop.

Commercially produced charts and posters are obtainable free of charge or at low cost from various manufacturers and metal processing companies. These visual materials range from decimal equivalent and tap drill size charts to posters illustrating the refining of metal. Sources of these teaching aids are listed in previous Selected Related Materials sections.

MOTION PICTURES

Excellent motion pictures which will enhance the metalworking program are available on loan from many companies and nonprofit institutions. These films add variety to the daily lessons, increase the motivation of students, and expand their range of knowledge. The motion picture, combining motion, color, and sound, can illustrate broad relationships between various facets of the metalworking industry: raw metallic ores extracted from the mines, processed at the furnaces, formed at the rolling mills, and fabricated at the manufacturing plants. Industrial processes can be depicted in a minimal period of time, and films can substitute for field trips when class excursions outside the school are impossible or impractical.

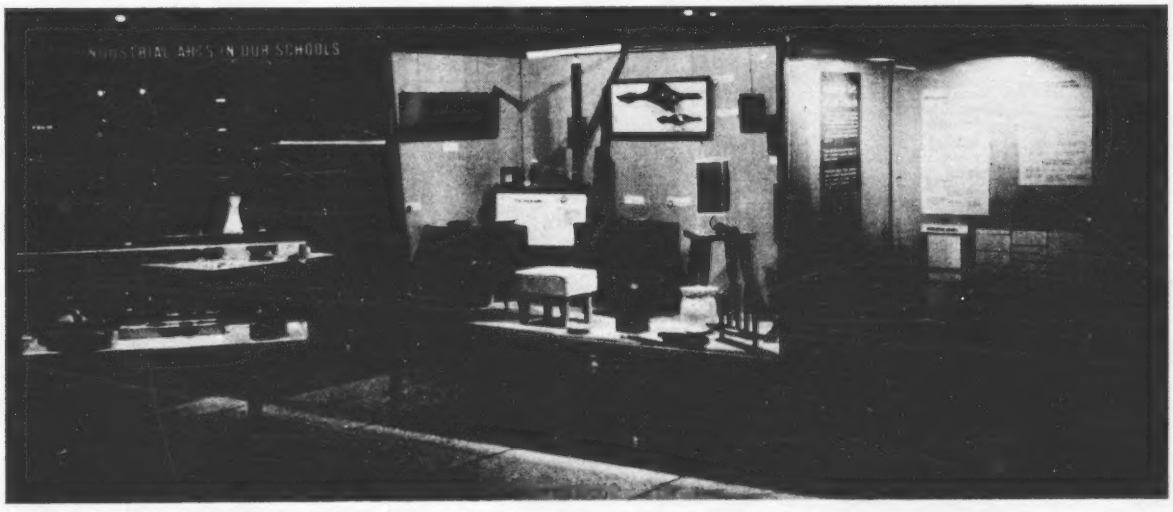
Motion pictures reinforce automation and mass production concepts. In addition, films show men in their working environment — the mines, steel mills, factories, research laboratories, and the machines they control to perform their assigned functions. This provides pupils with occupational information on which to base career choices.

To make the most effective use of the motion picture as an audiovisual aid, the instructor should preview the film so that the students can be prepared to watch for specific highlights during the showing. A follow-up after the presentation, a short quiz, discussion, or written report will increase the value of the learning experience. Reordering of films for future showings can be expedited by the development of a card file containing pertinent information: film title, running time, film source, description of main theme, and a brief evaluation concerning strengths, weaknesses, and suitability of film according to grade levels.

SINGLE CONCEPT FILMLOOPS

The single concept filmloop is a valuable educational medium in the metalworking shop. Because of the multitude of hand and machine skills listed in the course of study and covered in the term's program, the filmloop can be of significant assistance in teaching a basic tool concept. The motion picture film, spliced in the form of a loop and housed in a cartridge, is readily inserted into the projector. The continuous loop feature enables the film to be repeated without rewinding or rethreading.

The convenience of the device and the speed at which the concept can be presented to an individual or small group make it an excellent instrument for review, particularly for the student who may have been absent when the concept was introduced. The filmloop can also supplement or reinforce formal demonstration. It



Industrial Arts exhibits display prize winning products designed and constructed by students in Industrial Arts programs in the New York City Schools

also increases motivation for learning and provides the means for self-instruction.

With the cooperation of the students in the class, single concept films can be produced within the metalworking shop and added to the permanent collection of the shop library. A committee of students can select the topic, plan the sequence by isolating each step of the process, consider the lighting problems, and cast the actor who will "star" as the operator or performer of the skill to be demonstrated. The relatively low cost of purchasing super 8 mm. film, processing, and installing the film in the cartridge allows the pupils to participate in a group activity which results in a substantial contribution to the resources of the metalworking shop.

OVERHEAD PROJECTOR

The overhead projector is increasingly being used by industrial arts teachers because it improves teaching efficiency. This device allows the instructor to face the class while projecting the transparency on the screen, and can be operated in a partially lighted room.

Transparencies can be purchased from commercial sources or may be prepared by the teacher. Acetate sheet, transparency mounts, and other accessories required in the making of transparencies can be requisitioned from the Bureau of Supplies' *Contract Data Sheets* and *Stocked Supplies Catalogue*. Overlays assist in the explanation of more complicated processes or more complex assemblies. An added advantage of being equipped with an expendable roll of transparent acetate is that the instructor can write technical terms or draw diagrams while presenting the lesson.

Valuable time and effort can be conserved if the teacher develops a series of transparencies to replace needed chalkboard drawings that have been repeatedly erased and redrawn. Transparencies that eliminate the chalkboard drawings can be indexed and ready for use in future lessons.

FIELD TRIPS

From the standpoint of learning and personal growth, field trips are one of the most effective teaching aids. Because field trips allow students to observe the technician, machine operator, designer, and other employees in a true-to-life situation, the educational experience can be positively rewarding. Visiting a factory with its concomitant movements, noises, and odors resulting from machine fabrication of materials affords the metalworking pupil a firsthand exposure to the industrial environment as it really exists.

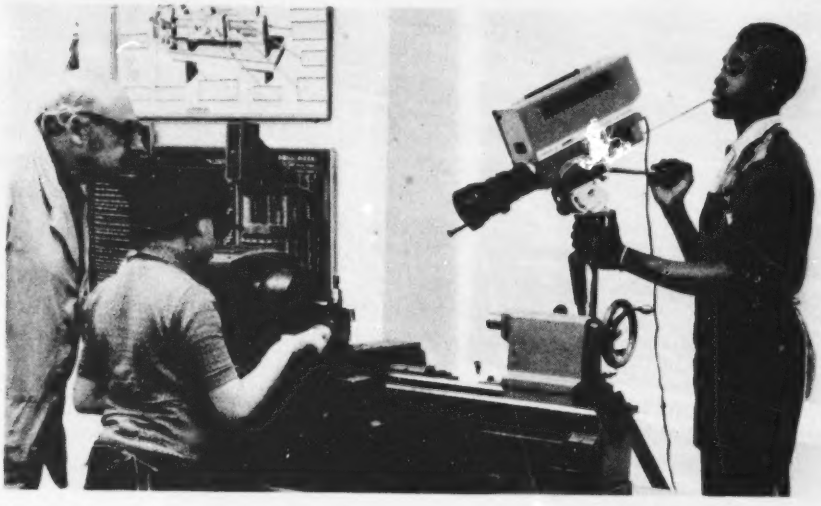
Commercial establishments located in the vicinity of the school make possible short visits where the practical applications of metalworking skills can be observed. Local field trips can include a class visit to a small machine shop, sheet metal shop, tool and die shop, or body and fender repair shop where tools and machines are being used by skilled workers. Field trips within the metropolitan area might include a visit to larger companies such as an automobile assembly plant, packaging plant, metal fabricating plant, foundry, or a large corporation which sponsors attractive exhibits displaying metal products. The classified telephone directory can furnish leads for possible visits to industrial firms that are located in the immediate vicinity of the school or in areas that are conveniently located in other sections of the city.

The field trip necessitates careful planning in order to insure that the objectives of the visit can be attained. This can be accomplished by some preliminary research on the part of the instructor who can phone, write, or preferably tour the facilities of a company so as to obtain, at least, minimal information which will provide him with a background prior to the class visitation. In addition, because safety is a prime consideration, students must be alerted to the possible hazards that might be encountered prior to, during, and after the trip. The importance of satisfactory behavior and proper attire must also be stressed.

To derive maximum educational value from a field trip, an effective follow-up is required. Key points should be reviewed and stressed through good questioning techniques. Class discussion should be encouraged so that pupils can share their experiences and express their observations and opinions. Another approach for following up the excursion is requesting a short, written report in which the student describes the field trip and evaluates the learning experience. This report can be inserted in the student's metalworking shop notebook, and used for future reference.

In New York City, there are specific regulations that must be followed before any class is conducted outside the confines of the school building. The principal must be apprised of the contemplated field trip so that it can be determined whether or not those classes that are assigned to the metalworking teacher can be covered. Once the principal's permission is granted,

parents' consent slips must be distributed to the class and returned with a parent's signature; the consent slips are then filed by the teacher who is supervising the trip. Other printed applications such as trip authorization and free transportation forms must be completed in advance.



Preparing a videotape recording of a lathe operation for future use. Videotape recording equipment is presently available in convenient and manageable units made possible through the miniaturization of electronic components.

CLOSED CIRCUIT TV AND VIDEOTAPE RECORDING

Closed circuit TV and videotape recording allow an innovative approach to teaching metalworking. Use of this equipment can improve instruction, increase motivation, and make the teaching process more efficient.

The closed circuit TV system functions with the use of the TV camera, microphone, and monitoring receiver. The video camera, equipped with a zoom lens, enables the teacher to demonstrate intricate tool and machine operations that would otherwise be difficult to show. For example, a lesson on the use of the jeweler's saw is enhanced as the TV camera zooms in to magnify the saw blade so that the direction of the teeth may be clearly discerned on the screen. The cutting action of the saw blade as it turns a corner of thin guage metal can also be readily seen with a close-up lens.

Overcrowded demonstration lessons can be relieved by use of the TV monitor. Instead of the entire class congregating around the particular machine or equipment, part of the class can view the demonstration on the TV screen.

The videotape recording system permits instant recording of sound and image on magnetic tape. The flexibility and versatility of this electronic device opens up a variety of uses in the metalworking shop.

Student motivation for learning is increased when the pupil can execute hand tool and machine skills in front of the video camera, and then review and analyze the performance by playing back the tape immediately. Another value of the videotape recorder is that it allows the making of single concept tapes which eliminate the need for processing required for motion picture single concept filmloops.

Flexibility is demonstrated by the completely portable, battery operated videotape recording system that can be operated by one person. It consists of a hand-held video camera connected to a shoulder-held videotape recorder enabling the operator to freely record both picture and sound. Thus, events that occur outside the metalworking shop, such as a field trip, can be recorded on tape, brought into the shop, and played back on a monitor for class viewing and discussion.

Videotape can be easily edited so that only essential portions are retained for future showings. When a tape no longer serves its purpose, it can be erased and reused for more pertinent material. Tapes can be added to the shop library collection. Videotape recording for individual and group instruction saves the teacher time and effort. However, while the system is recognized as a valuable audiovisual teaching aid, in no way does it replace the personal element that is so essential in effective teaching.

SELECTED RELATED MATERIALS

TEACHING AIDS

Industrial Literature (catalogs of free literature)

Aluminum Company of America, 818 Alcoa Building, Pittsburgh, Pa. 15219.
American Iron and Steel Institute, 150 East 42nd St., New York, N.Y. 10017.
Educators Guide to Free Curriculum Materials. Educators Progress Service, Randolph, Wisc. 53956.
General Motors Corporation, Public Relations Staff, General Motors Building, Detroit, Mich. 48202.
United States Steel Corporation, 71 Broadway, New York, N. Y. 10006.

Motion Pictures (catalogs of films)

American Iron and Steel Institute, 150 East 42nd Street, New York, N.Y. 10017.
Educators Guide to Free Curriculum Materials. Educators Progress Service, Randolph, Wisc. 53956.
Film Services for New York City Schools. Center for Library, Media & Telecommunications, Board of Education of the City of New York, 131 Livingston St., Brooklyn, N.Y. 11201.
Modern Talking Picture Service, 2323 New Hyde Park Road, New Hyde Park, N. Y. 11040.

Single Concept Filmloops (commercial catalogs)

McGraw-Hill Book Company, 330 West 42nd St., New York, N. Y. 10036.
Sterling Educational Films, Inc., 241 East 34th St., New York, N. Y. 10016.
Universal Education & Visual Arts, 221 Park Avenue South, New York, N. Y. 10003.

Field Trips

Trips for New York City Classes, 1968 (reprinted 1969, 1975). Center for Curriculum Development, Board of Education of the City of New York, 131 Livingston St., Brooklyn, N. Y. 11201.
Open Doors: A Guide to Business Resources Available for New York Schools. Public Education Association, 20 West 40th St., New York, N. Y. 10018.
A Teachers Directory to New York City's Museums, Zoos, and Botanical Gardens, 1976. *Dissemination Unit.*

Closed Circuit TV and Videotape

Video Tape Applications in Education and Training (portfolio of magazine articles). SONY Corporation of America, 44-47 Van Dam St., Long Island City, N. Y. 11101.

SELECTED BIBLIOGRAPHY

Books

The following textbooks and reference books are included in the New York City Board of Education *Approved Textbook List* and can be requisitioned through the school. The industrial arts supervisor or school librarian should be consulted when ordering books for the metalworking shop.

07-004149-0	Baster: *Jewelry, Gem Cutting and Metalcraft*, 3rd. ed., 1950.
7195-2572-1	Bedford: *Metalwork Projects*, 1963.
7195-2251-X	Bedford: *Metalcraft, Theory and Practice*, 1967.
910280-01.9	Bovin: *Jewelry Making*, rev. ed., 1971.
910280-03.7	Bovin: *Silversmithing and Art Metal*, rev. ed., 1971.
87006-133-X	Boyd: *Metalworking*, 1968.
442-31298-9	Brynner: *Modern Jewelry*, 1968.
517-02445-4	Choate: *Creative Casting*, 1966.
87345-142-2	Daniele: *Early American Metal Projects*, 1971.
07-020365-2	Feirer: *General Metals*, 3rd ed., 1967.
87002-048-X	Feirer: *Metalworking Student Guide*, 1970.
87345-175-9	Franke: *Handwrought Jewelry*, 1962.
13-350546-4	Fraser-Bedell: *General Metal*, 2nd ed., 1962.
87345-499-5	Gerbracht-Robinson: *Understanding America's Industries*, 1971.
02-817050-4	Giachino-Schoenthals: *General Metals for Technology*, 1964.
87002-157-5	Hawkins: *Art Metal and Enameling*, 1974.
87002-021-8	Johnson: *Technical Metals*, 1968.
87002-019-6	Johnson: *General-Industrial: Machine Shop*, 1970.
7195-0809-6	Larkman: *Contemporary Design in Metalwork*, 1963.
7195-1841-5	Larkman: *Metalwork Designs of Today*, 1969.
87002-263-6	Lindbeck: *General Industry*, 1969.
87345-113-9	Ludwig-McCarthy: *Metalwork Technology and Practice*, 1969.
87345-550-9	Lux-Ray: *World of Manufacturing*, 1971.
87345-150-3	McCarthy-Smith: *Machine Tool Technology*, 1968.
8069-5149-4	Meriel-Bussy: *Repoussage: Embossing of Metal*, 1970.
517-02560-4	Rothenberg: *Metal Enameling*, 1969.
87345-135-X	Ruley: *Projects in General Metalwork*, 1968.
87345-137-6	Ruley: *Practical Metal Projects*, 1970.
87345-495-2	Smith-Maddox: *Elements of American Industry*, 1966.
263-51531-1	Wainright: *Discovering Lapidary Work*, 1971.
87006-157-7	Walker: *Exploring Metalworking*, 1972.
87006-102-X	Walker: *Machining Fundamentals*, 1969.
8069-5063-3	Zechlin: *Creative Enameling and Jewelry Making*, 1965.